ANZA

SEISMIC NETWORK

Dbshear and Dbmw

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2016 08 17 AUG Fairbanks

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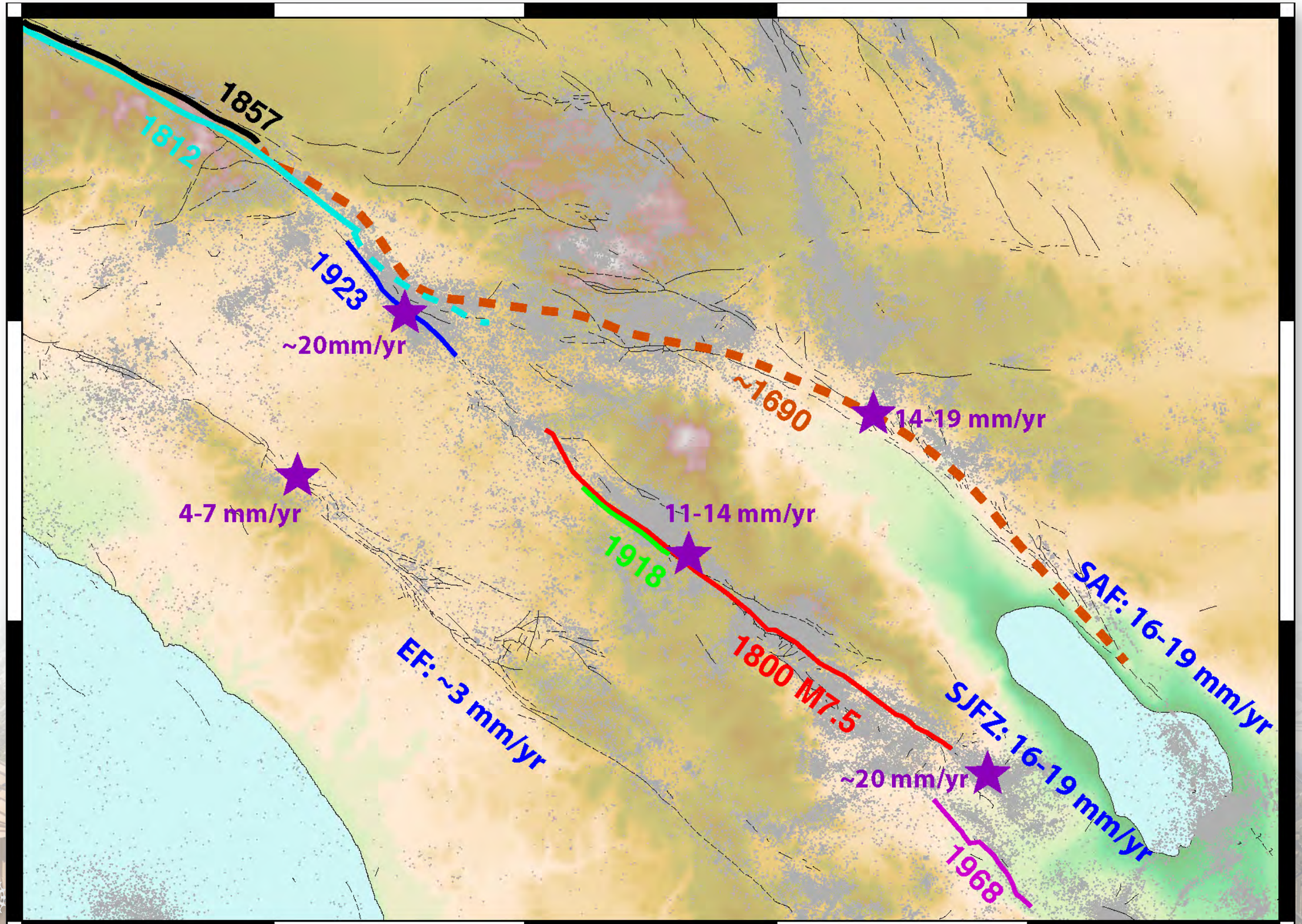
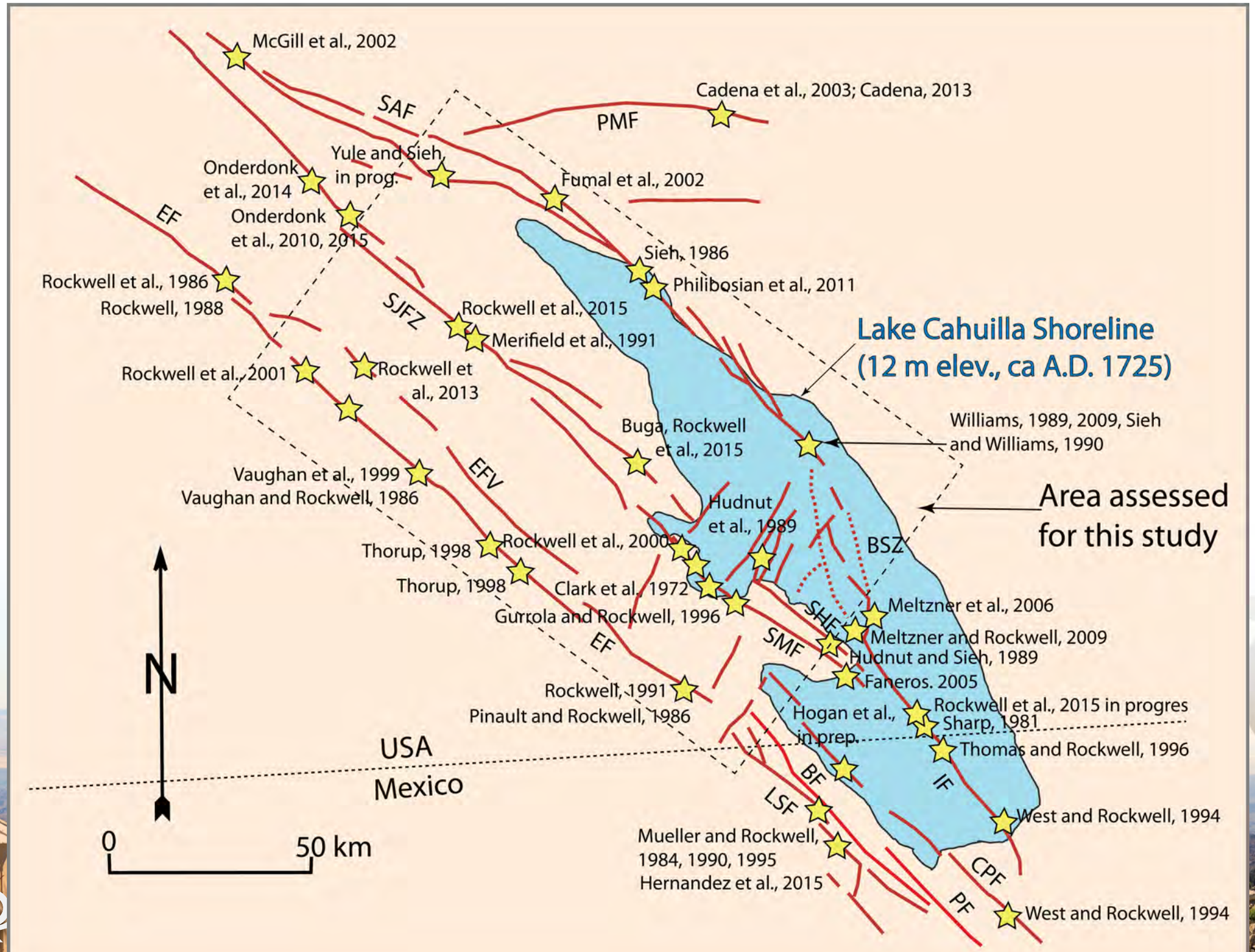
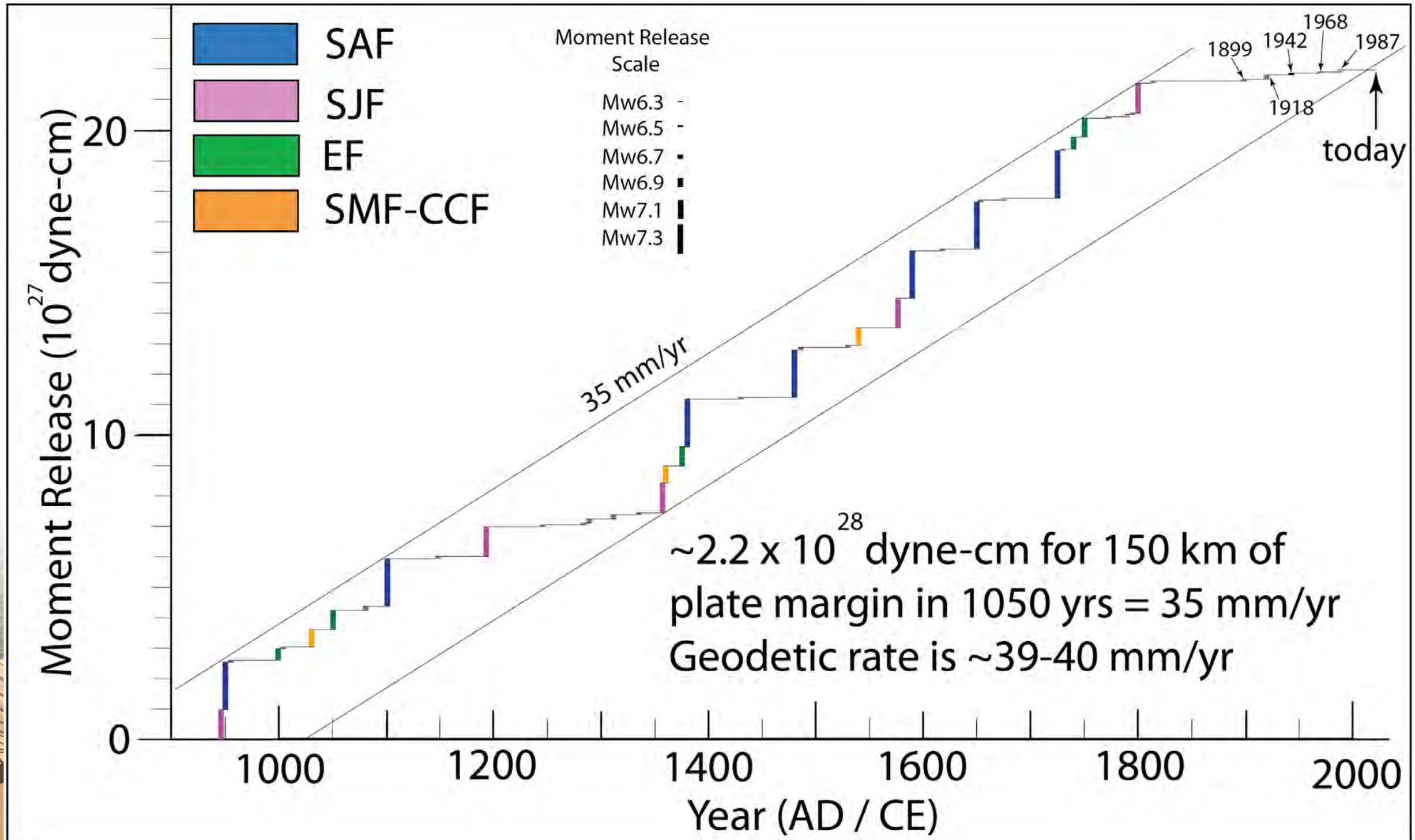
Southern California Major Ruptures



Southern California Paleoseismic Sites - Rockwell 2015



Southern California Pre-Historical Moment Release - Rockwell 2015



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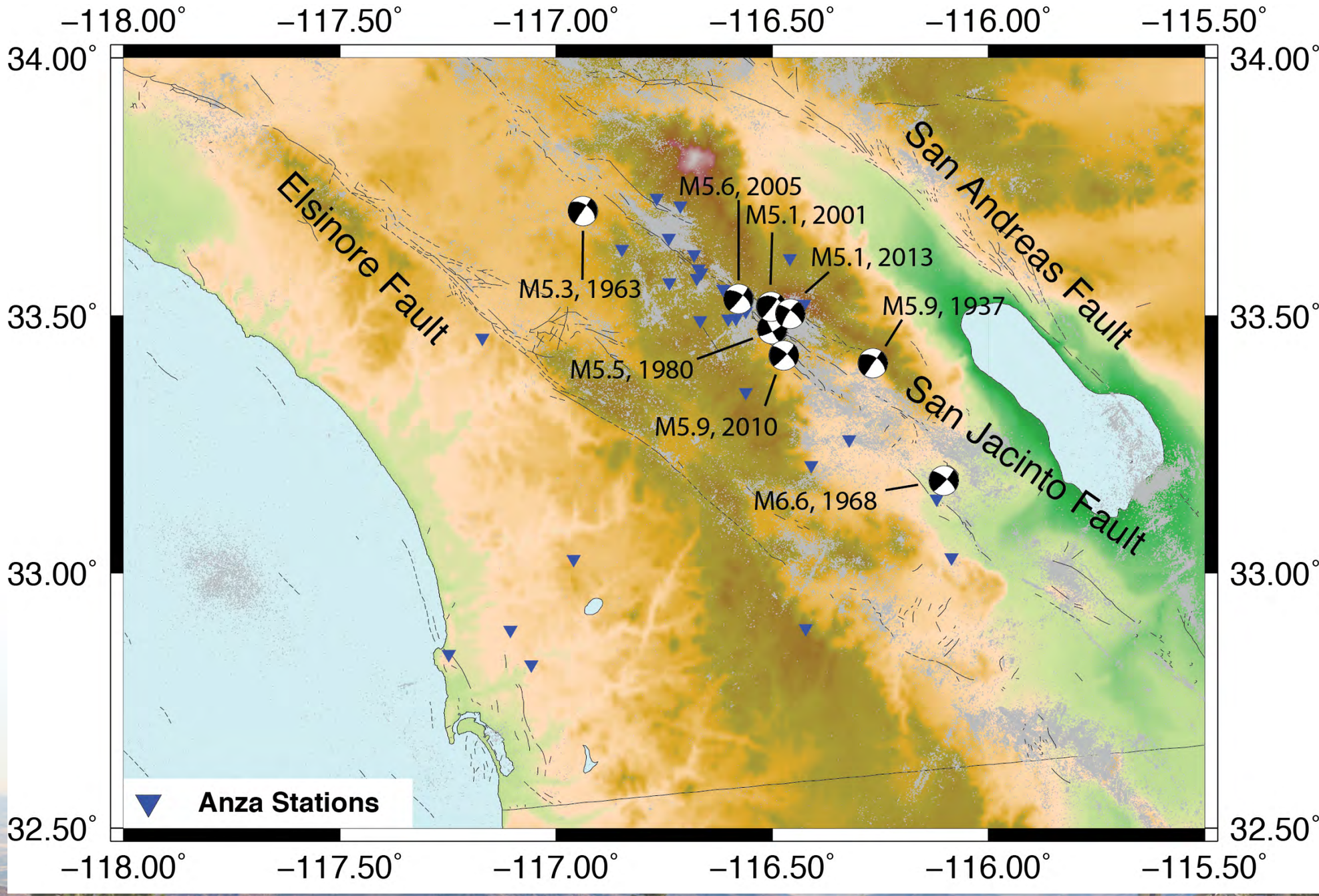
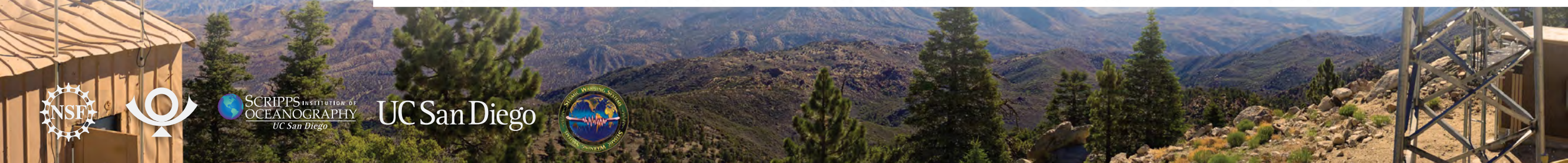
SEISMIC NETWORK

San Jacinto Fault M > 5

- 1937-1980
  4 events
- 1981-2000
  0 events
- 2001-2013
  4 events
- 2016
  1 event
  (*so far*)





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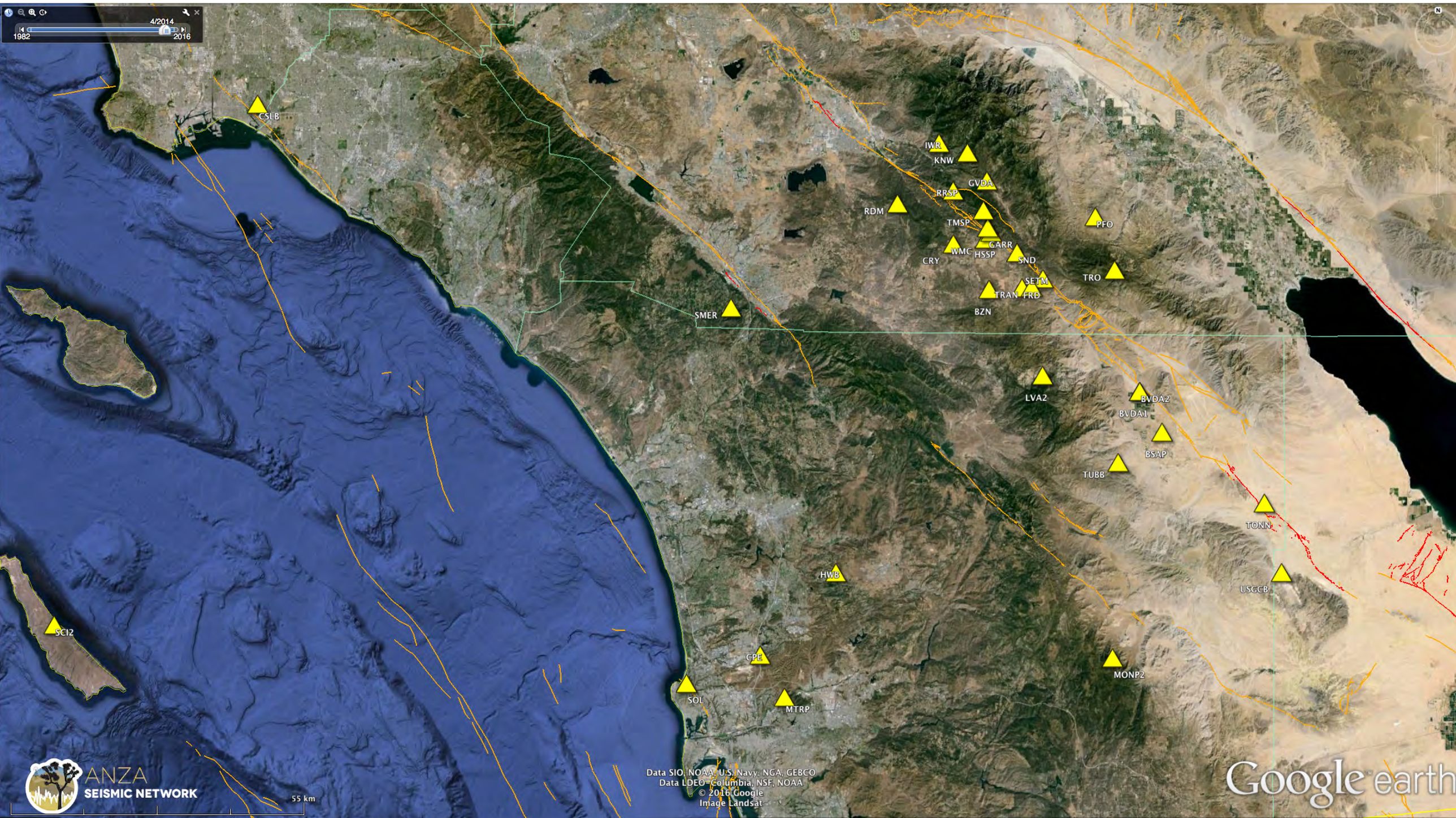
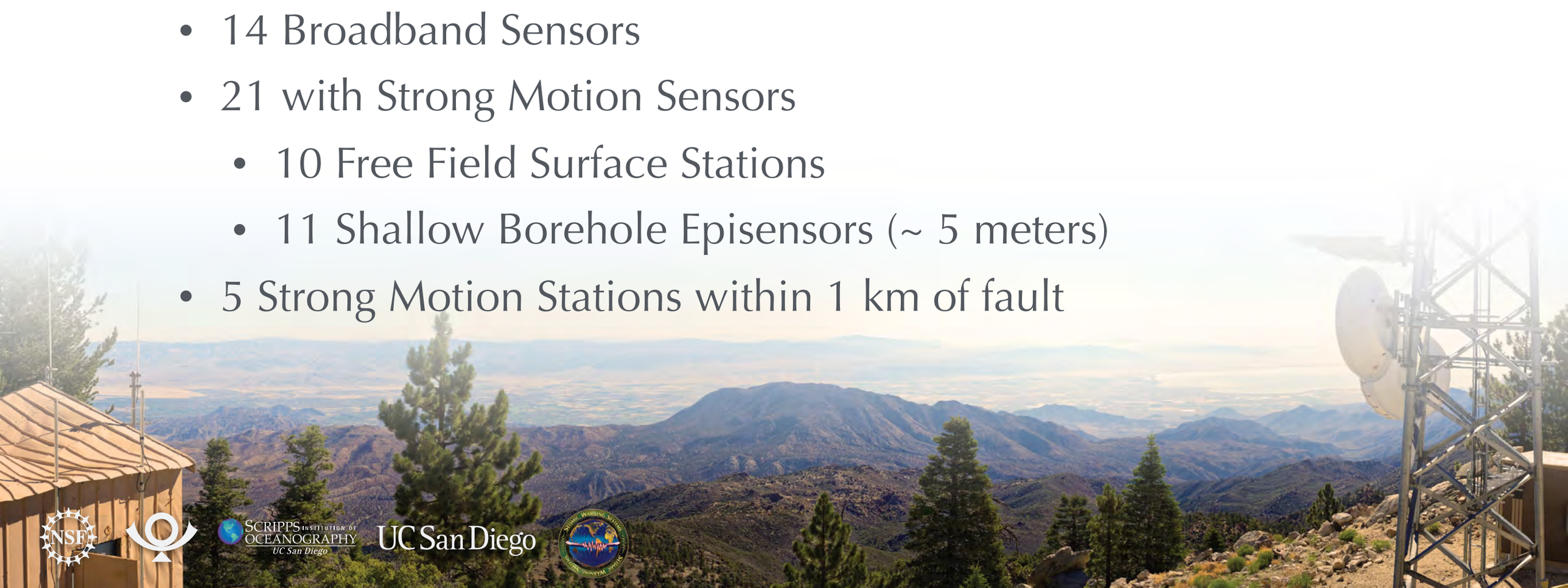
2010-present ANZA Phase 6



ANZA Current Configuration

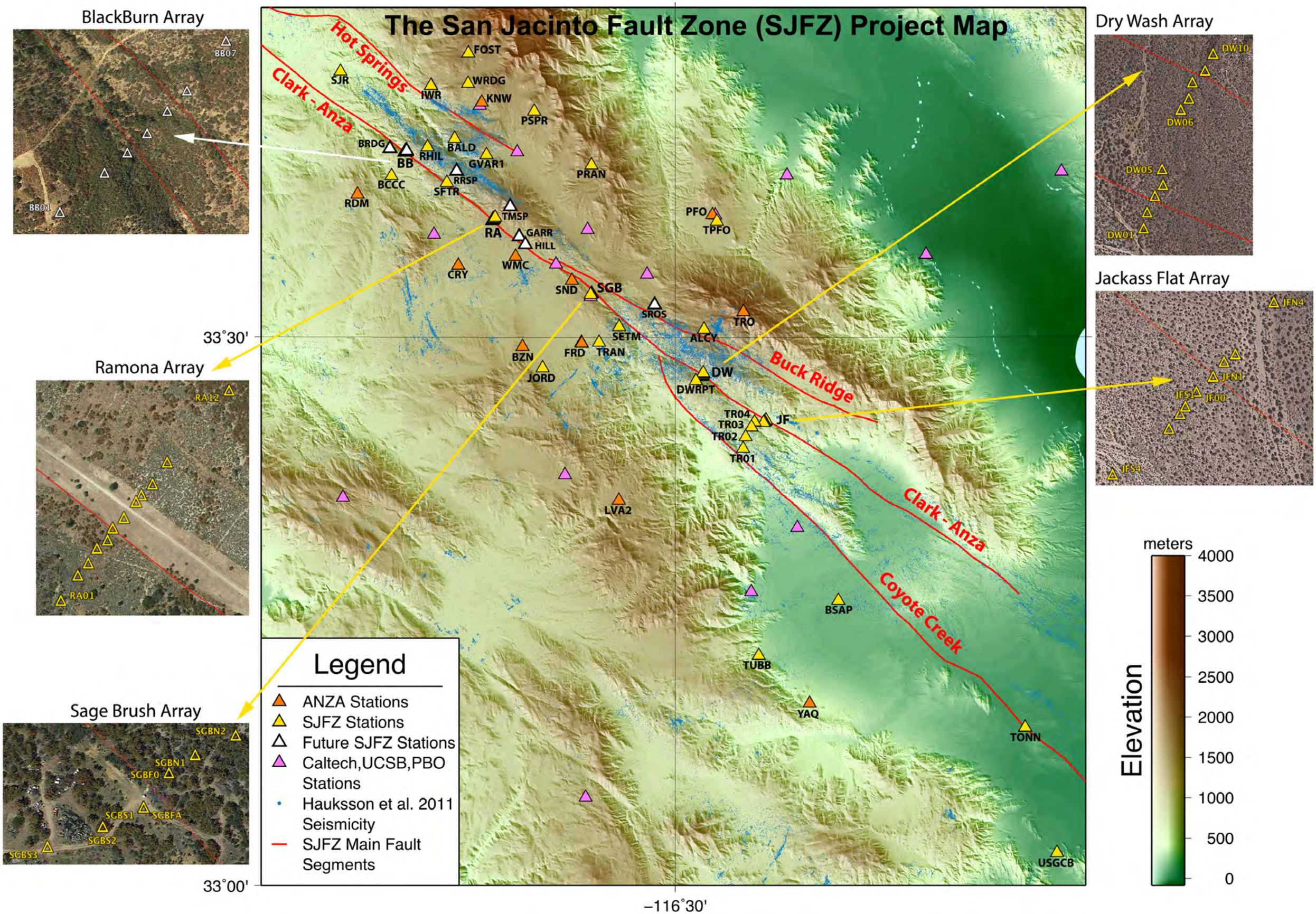
- 29 stations in network in remote locations
  - wireless telemetry
  - solar powered, battery backup
  - low power equipment
  - onsite storage
- 22 stations within 15 km of San Jacinto Fault
  - 14 Broadband Sensors
  - 21 with Strong Motion Sensors
    - 10 Free Field Surface Stations
    - 11 Shallow Borehole Episensors (~ 5 meters)
- 5 Strong Motion Stations within 1 km of fault



The SJFZ Project Deployment Map

ANZA

SEISMIC NETWORK



PASSCAL Ad Hoc Telemetry

HPWREN topology – January 2015

155Mbps FDX 6 GHz FCC licensed
155Mbps FDX 11 GHz FCC licensed
45Mbps FDX 6 GHz FCC licensed
45Mbps FDX 11 GHz FCC licensed
45Mbps FDX 5.8 GHz unlicensed
45Mbps-class HDX 4.9GHz
45Mbps-class HDX 5.8GHz unlicensed
~8Mbps HDX 2.4/5.8 GHz unlicensed
~3Mbps HDX 2.4 GHz unlicensed
115kbps HDX 900 MHz unlicensed
56kbps via RCS network
via Tribal Digital Village Network

dashed = planned

WIDC
KYVW
KNW
B081
GVDA
BDC
PFO
WMC
Santa Rosa
RDM
CRY
SND
AZRY
BZN
FRD
KSW
SMER
P474
MPO
SO
LVA2
DHL
SLMS
SCS
BVDA
P486
GLRS
P478
MTGY
MVFD
P510
P483
CRRS
WLA
GMPK
DSME
RMNA
CWC
USGC
P506
P499
P480
P509
CE
MONP
MLO
UCSD
DESC
P497
P494
IID2
70+ miles to SCI
P473
SDSU
P500
CNM
PL
POTR
P066
NSSS
to CI and PEMEX

Primary Backbone site
Relay node
Astronomy science site
Biology science site
Earth science site
University site
Researcher location
Native American site
Public Safety site

approximately 50 miles:

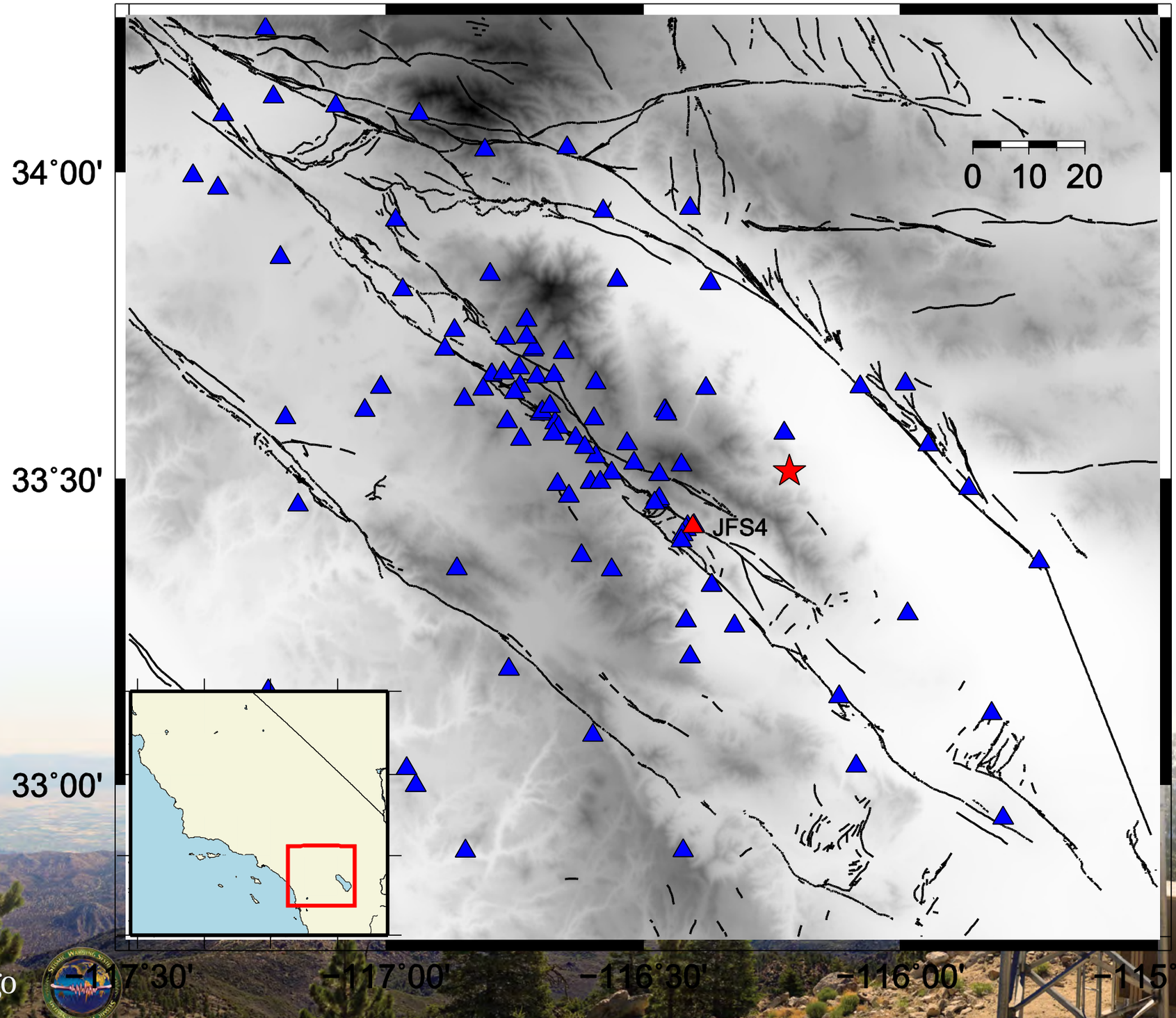
Note: locations are approximate

Applied Network Research

http://anr.ucsd.edu

SJFZ Virtual Network

- 123 stations
- AZ, CI, PB, SB, YN networks



Dbshear references

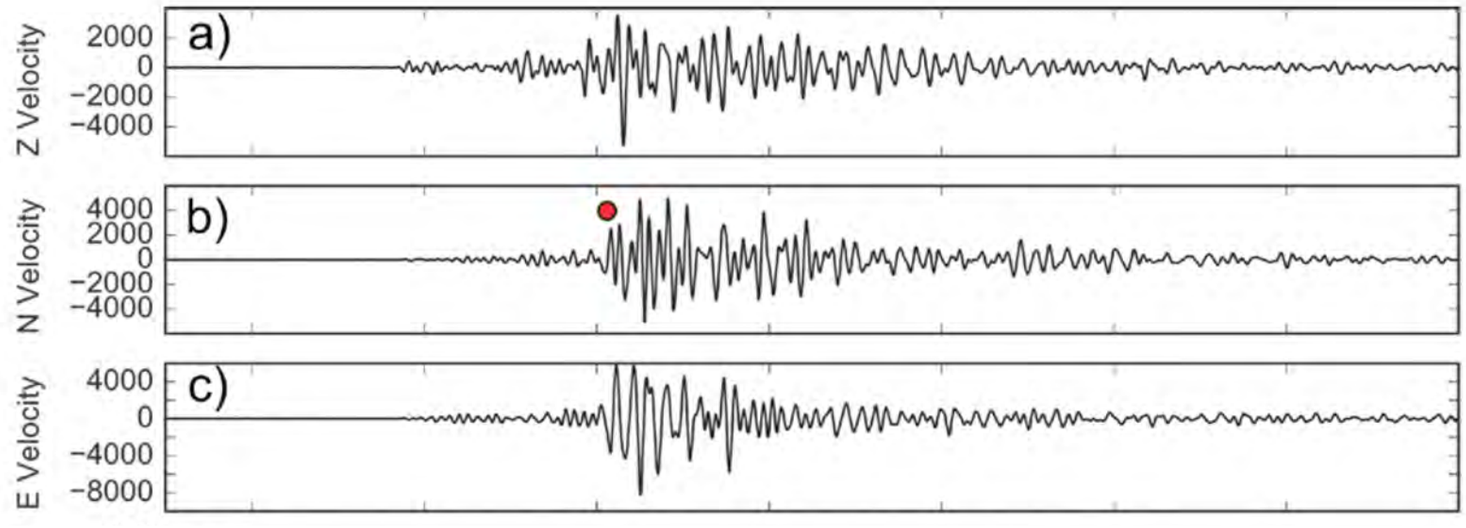
- Based on Ross and Ben-Zion (2014). *Automatic picking of direct P, S seismic phases and fault zone head waves, Geophys. J. Int.*
- Ross et al. (2016). *An improved algorithm for real-time S-wave picking with application to the (augmented) ANZA network in southern California, BSSA accepted*

Dbshear method

The method has three stages, which can be summarized as follows:

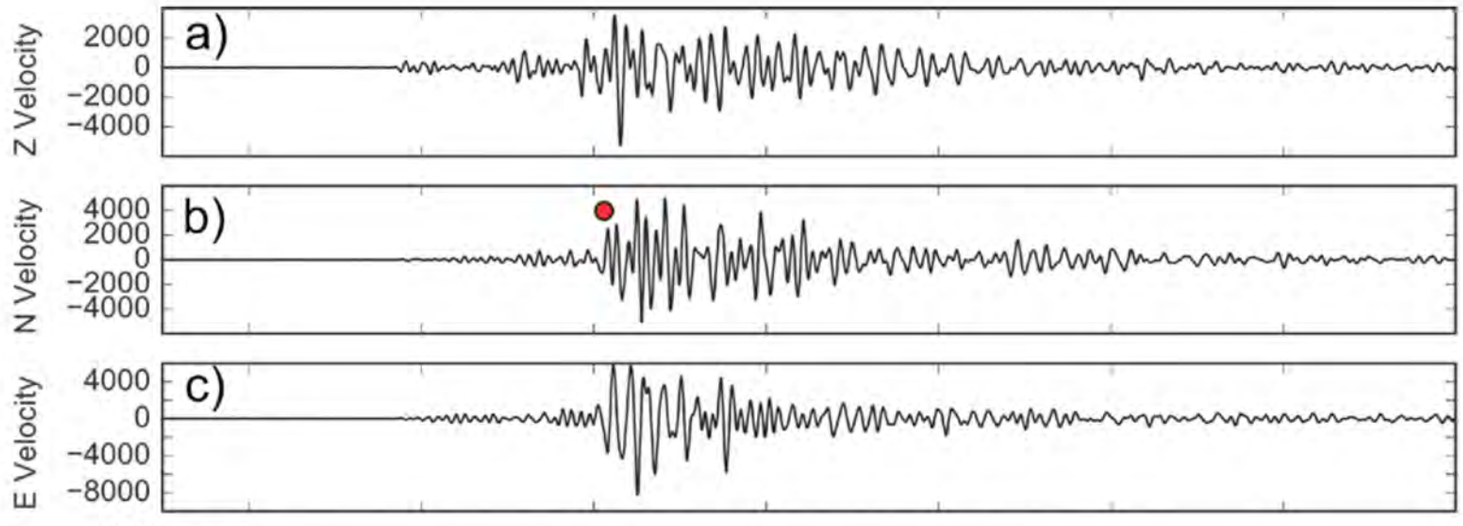
- use polarization analysis on a 3-component time series to remove P-wave energy from the seismogram
- use STA/LTA detectors on the resulting polarized horizontal traces to make a trial S-pick in the vicinity of the S-wave
- use kurtosis detectors in conjunction with the trial pick to lock on the S-arrival.
  - 4th order statistical moment and measures peakedness

S-Wave detector



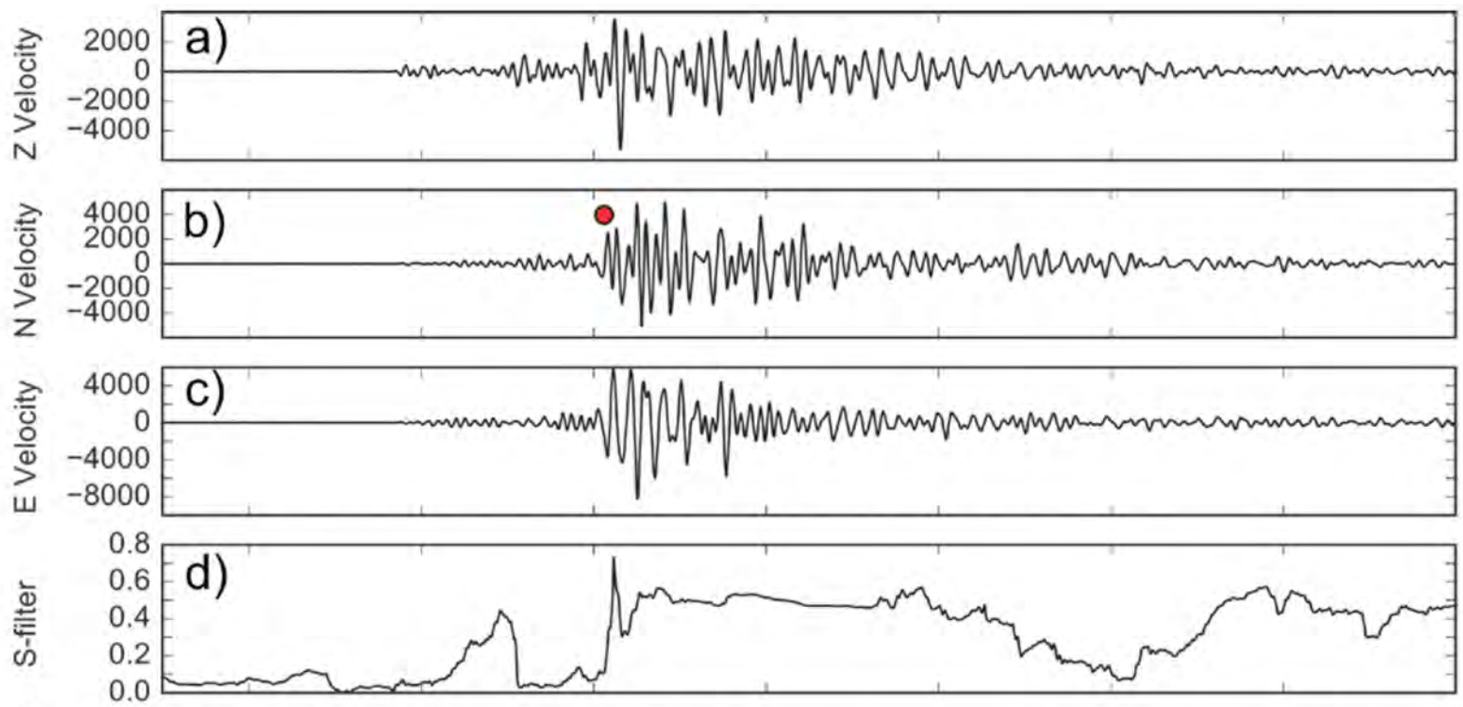
S-Wave detector

- 3 component seismic data



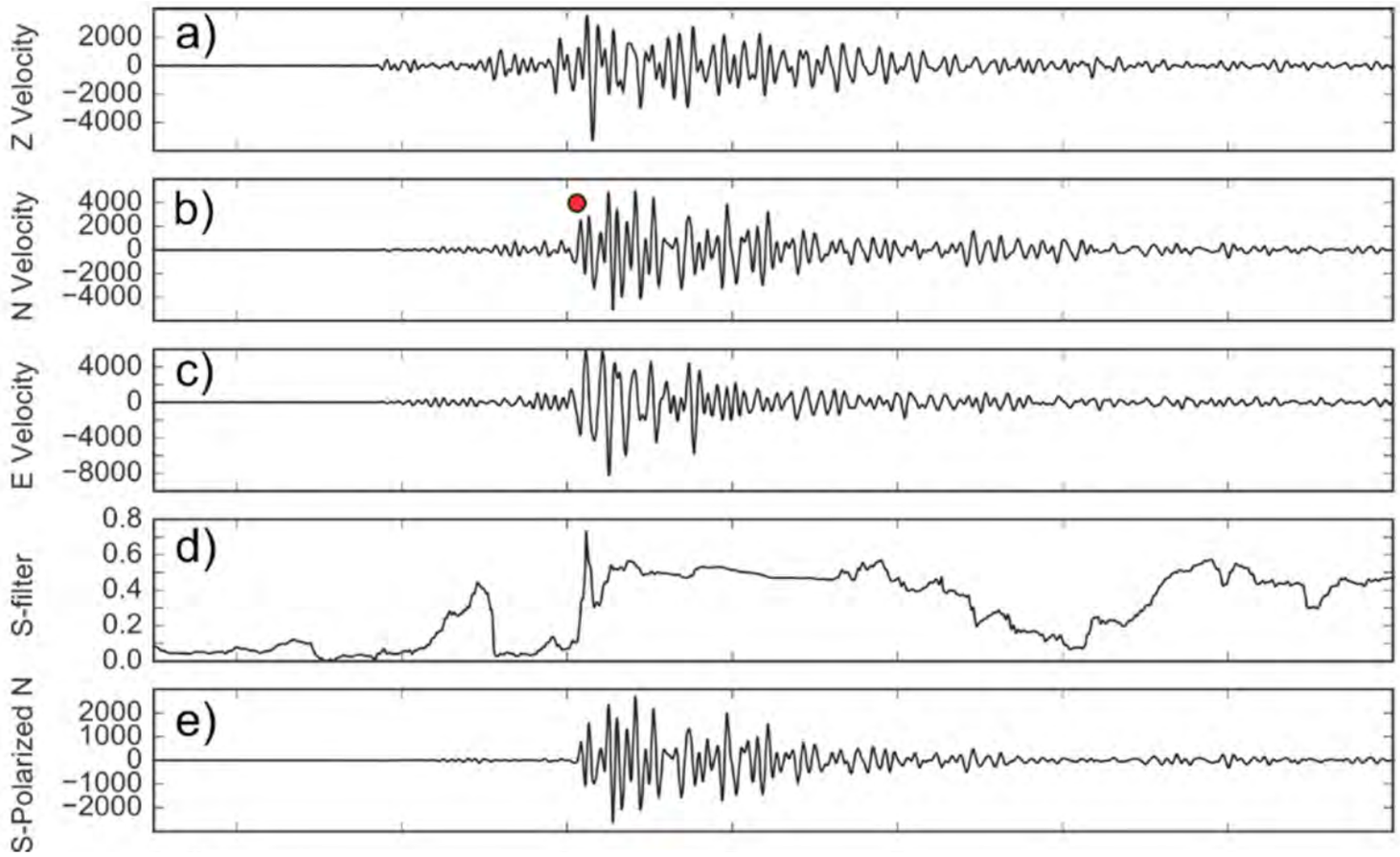
S-Wave detector

- 3 component seismic data
- S polarization filter



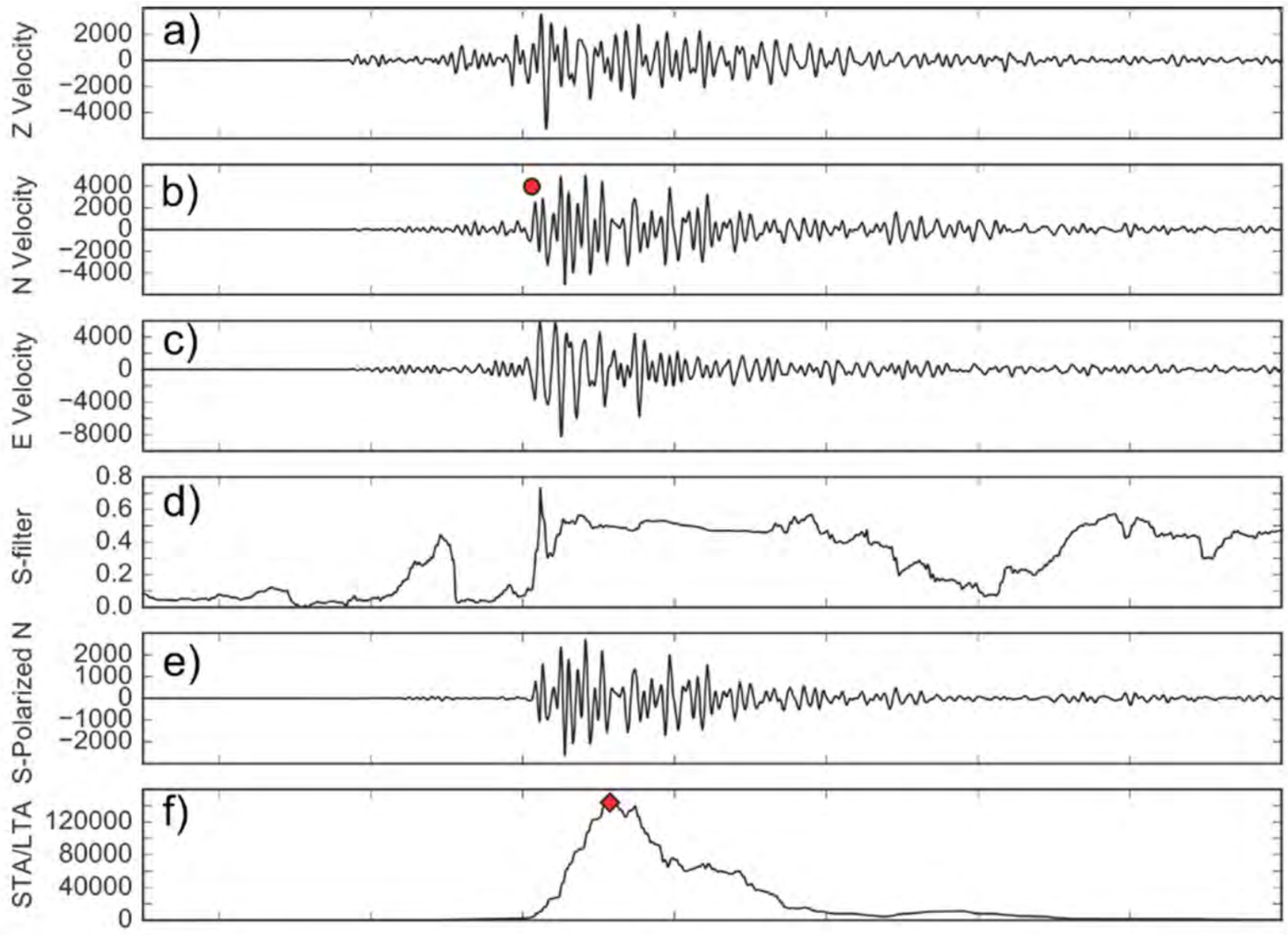
S-Wave detector

- 3 component seismic data
- S polarization filter
- S filtered N-S channel



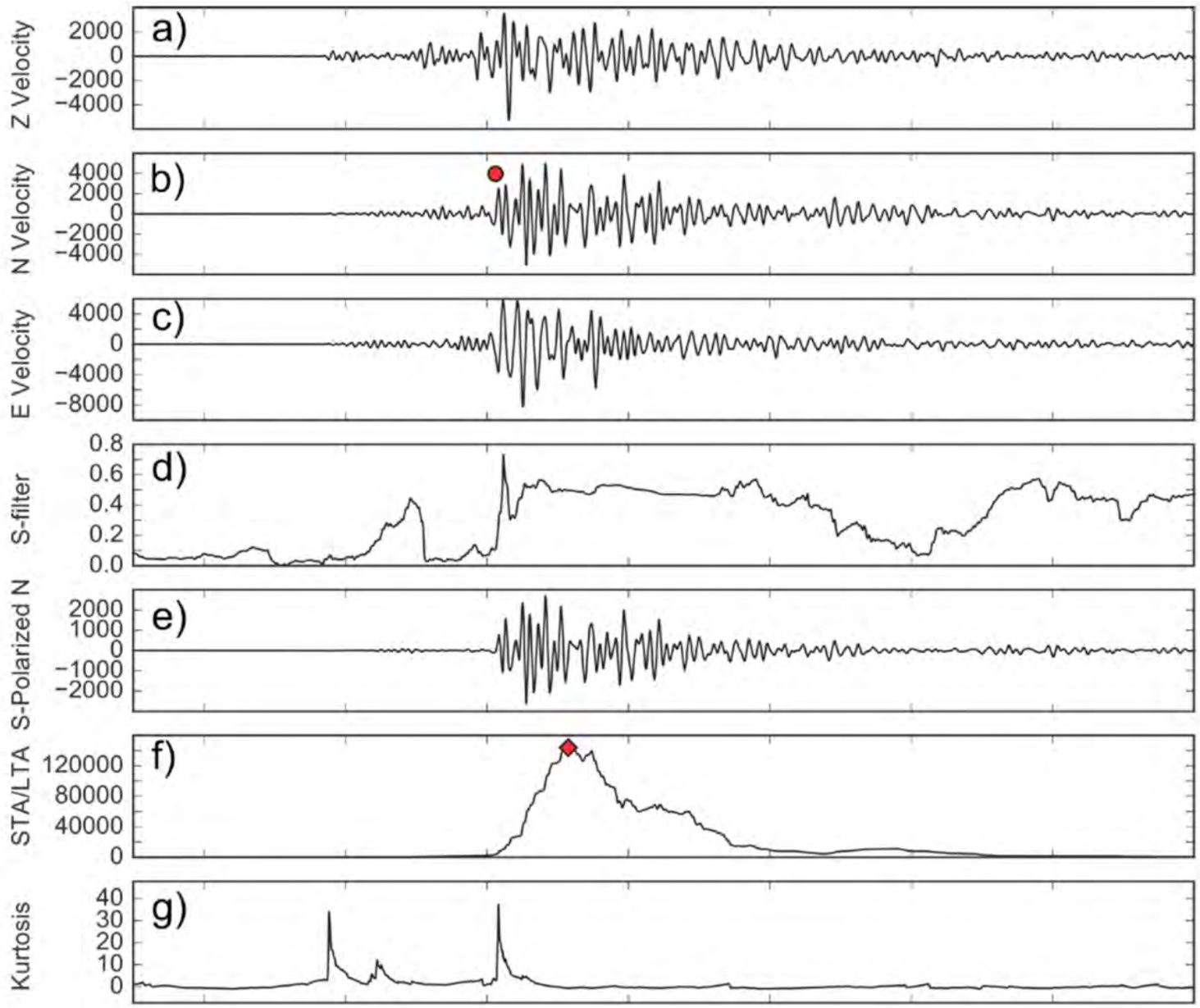
S-Wave detector

- 3 component seismic data
- S polarization filter
- S filtered N-S channel
- smoothed STA/LTA



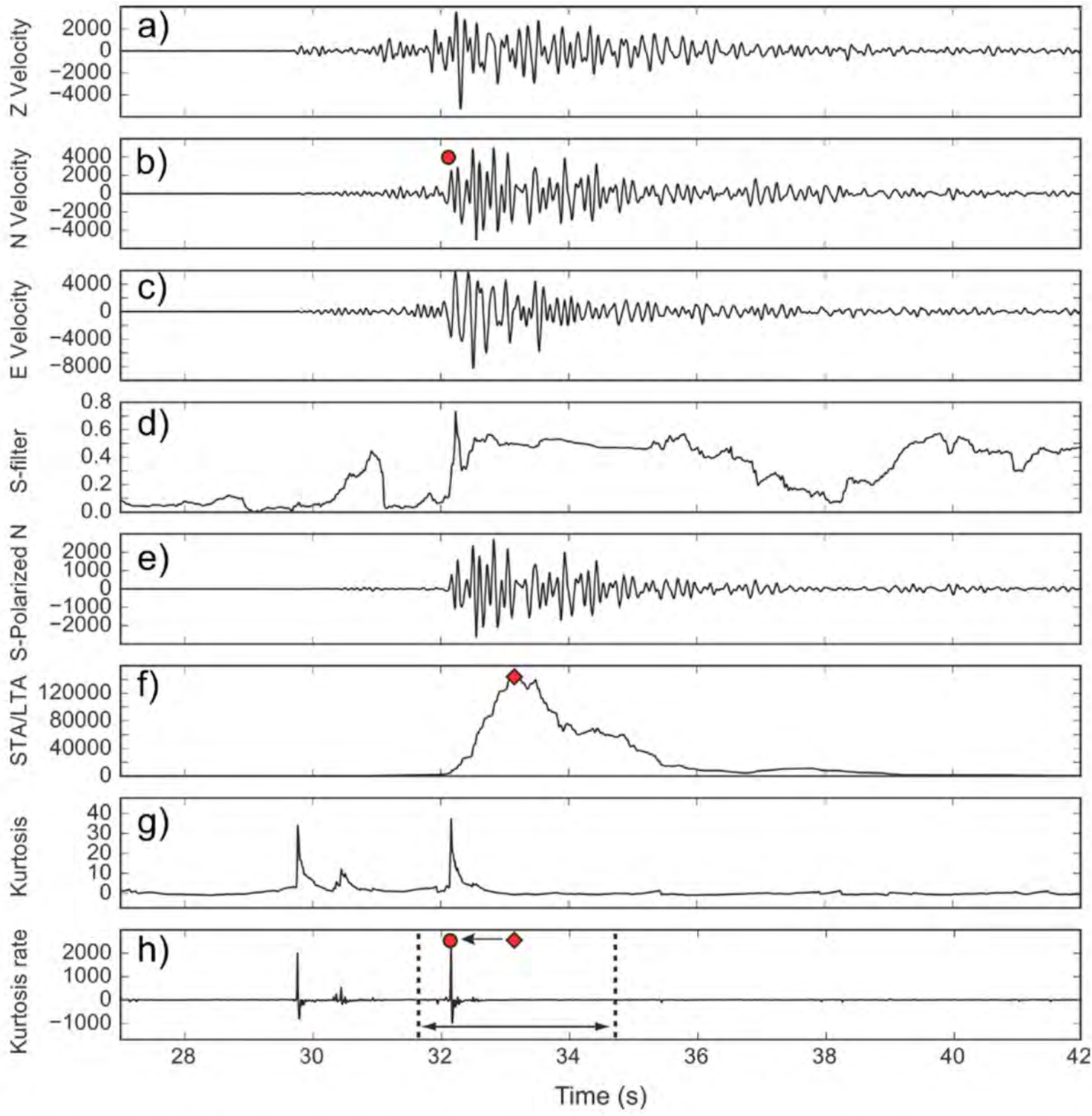
S-Wave detector

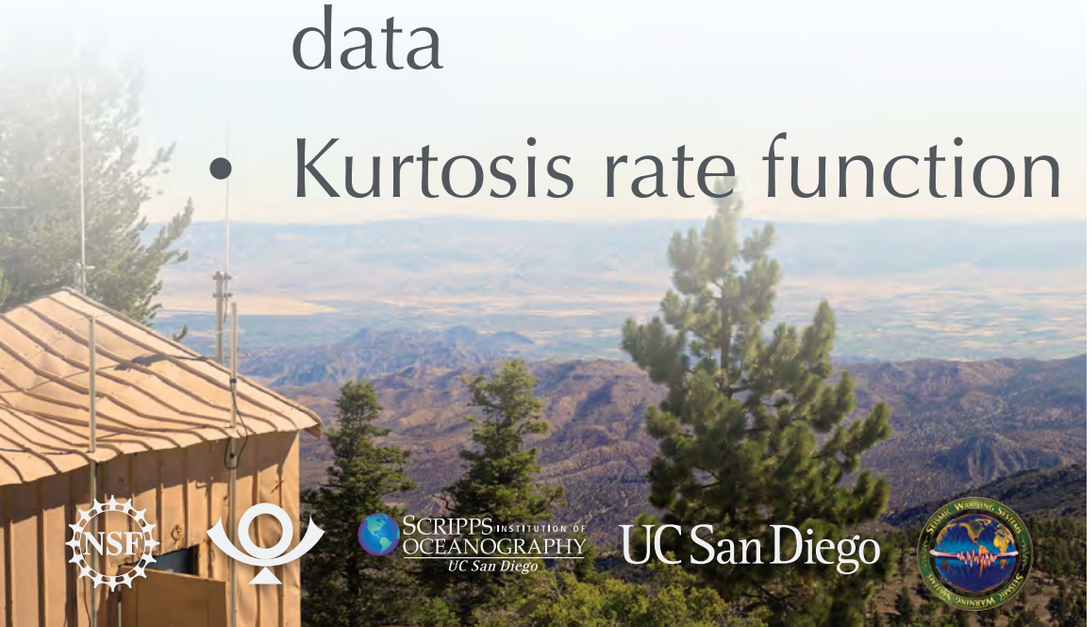
- 3 component seismic data
- S polarization filter
- S filtered N-S channel
- smoothed STA/LTA
- Kurtosis of filtered data



S-Wave detector

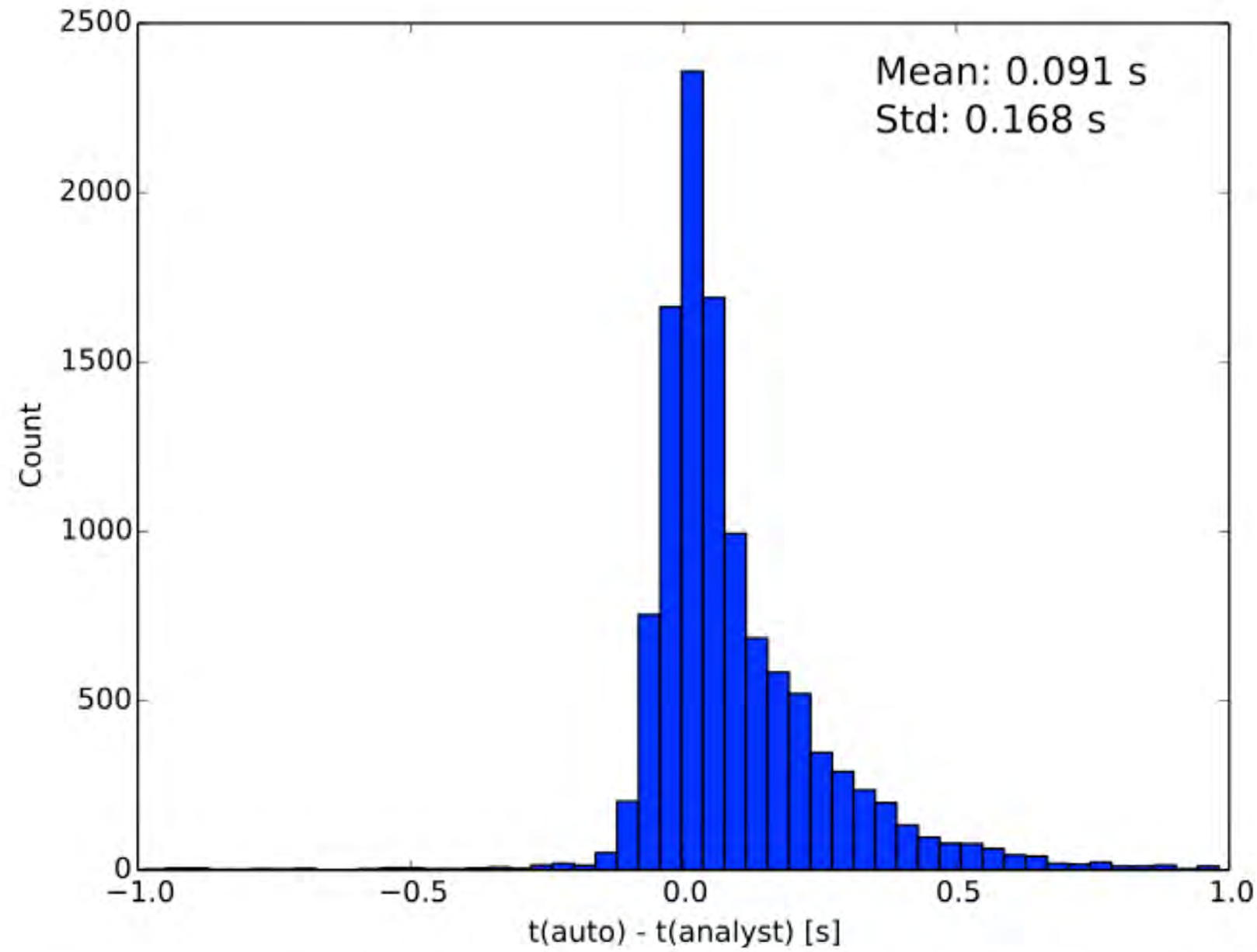
- 3 component seismic data
- S polarization filter
- S filtered N-S channel
- smoothed STA/LTA
- Kurtosis of filtered data
- Kurtosis rate function





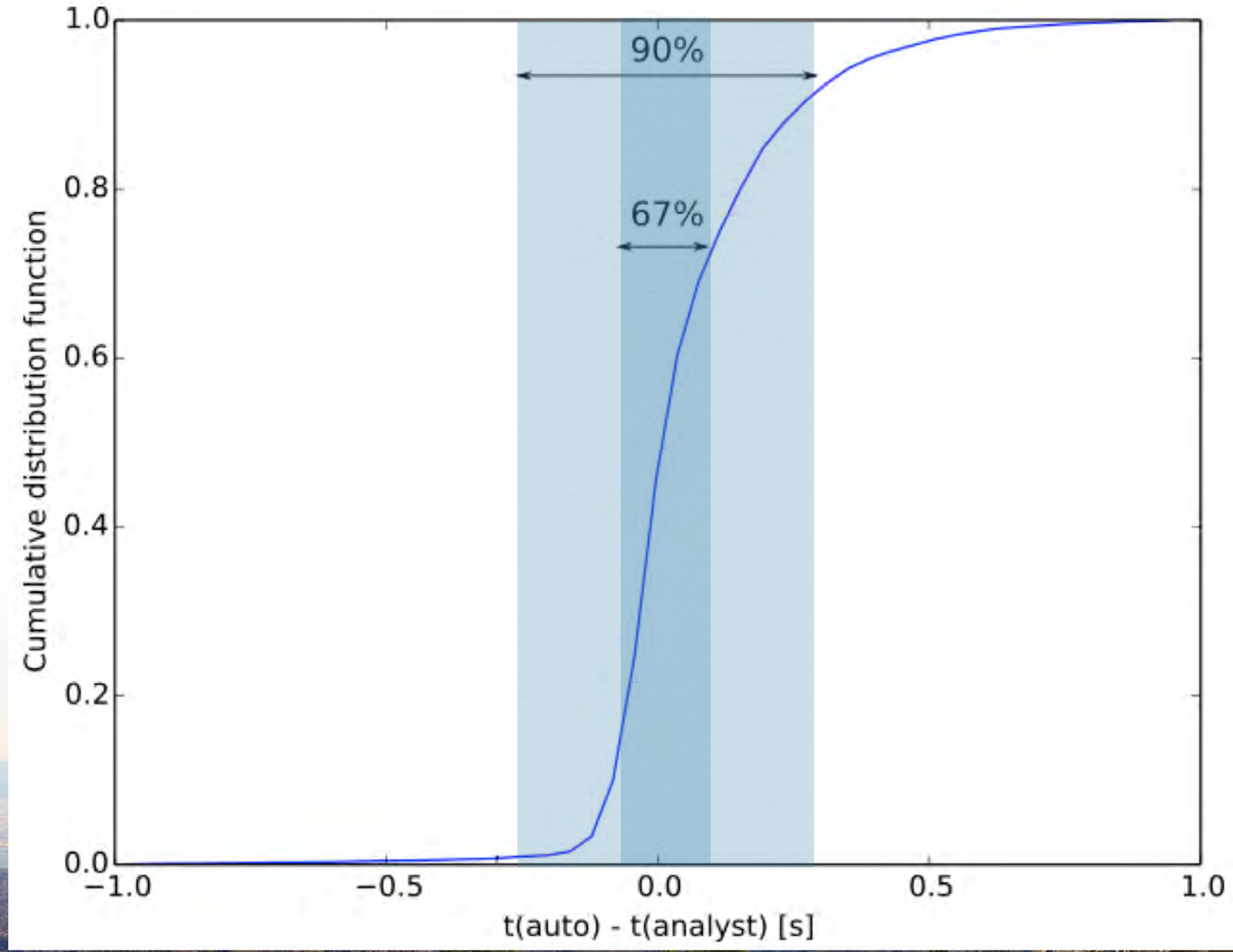
Comparing Analyst - Automatic S Picks

- 123 Stations
- One month data
- 11,353 S wave picks
- 0.09 ± 0.168 s
  - slightly biased
  - skewed distribution



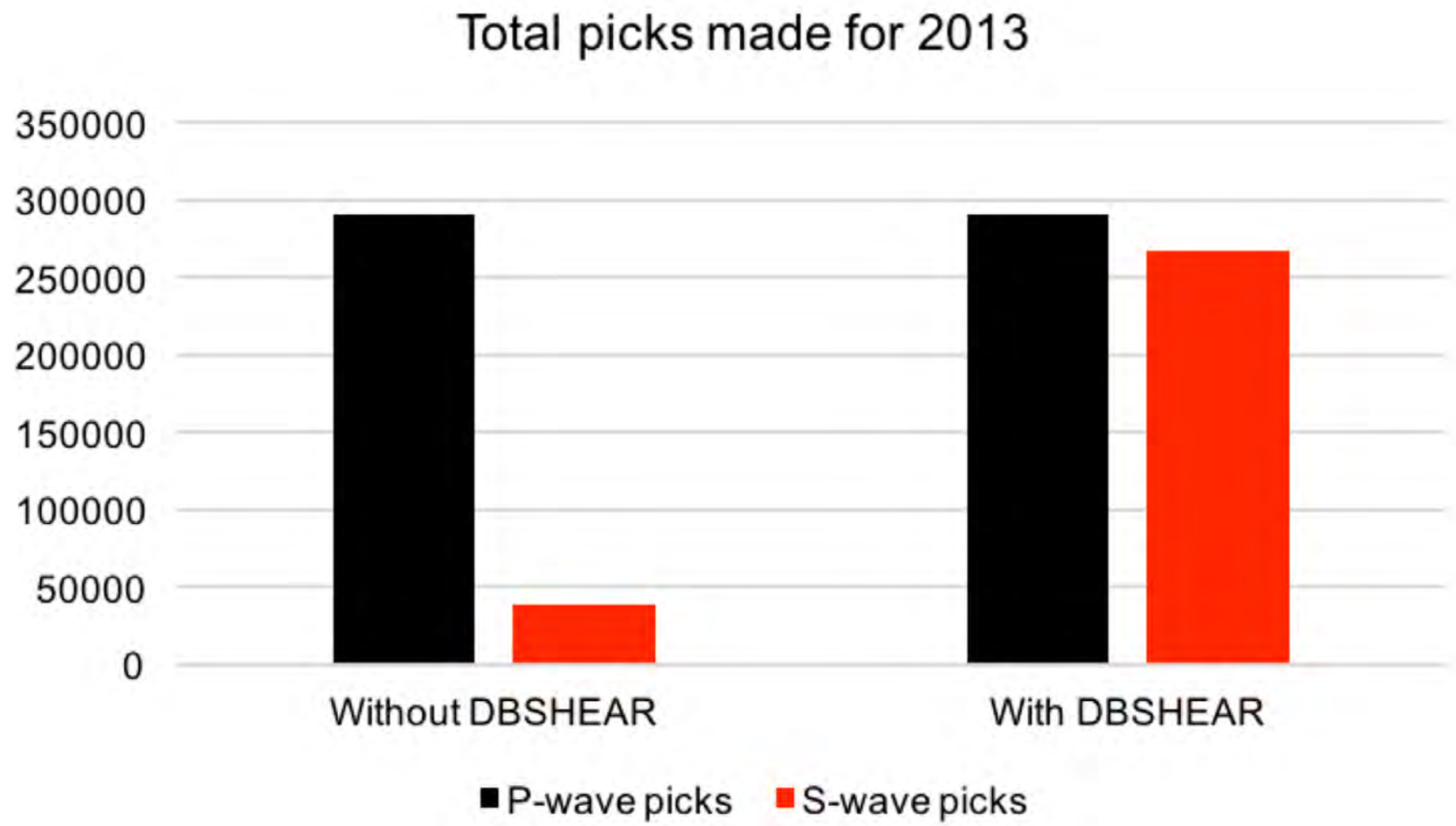
Empirical Cumulative Distribution Function

- 123 Stations
- 11,353 picks
- < 0.06 sec 50%
- < 0.11 sec 67%
- < 0.31 sec 90%



2013 SJFZ Processing

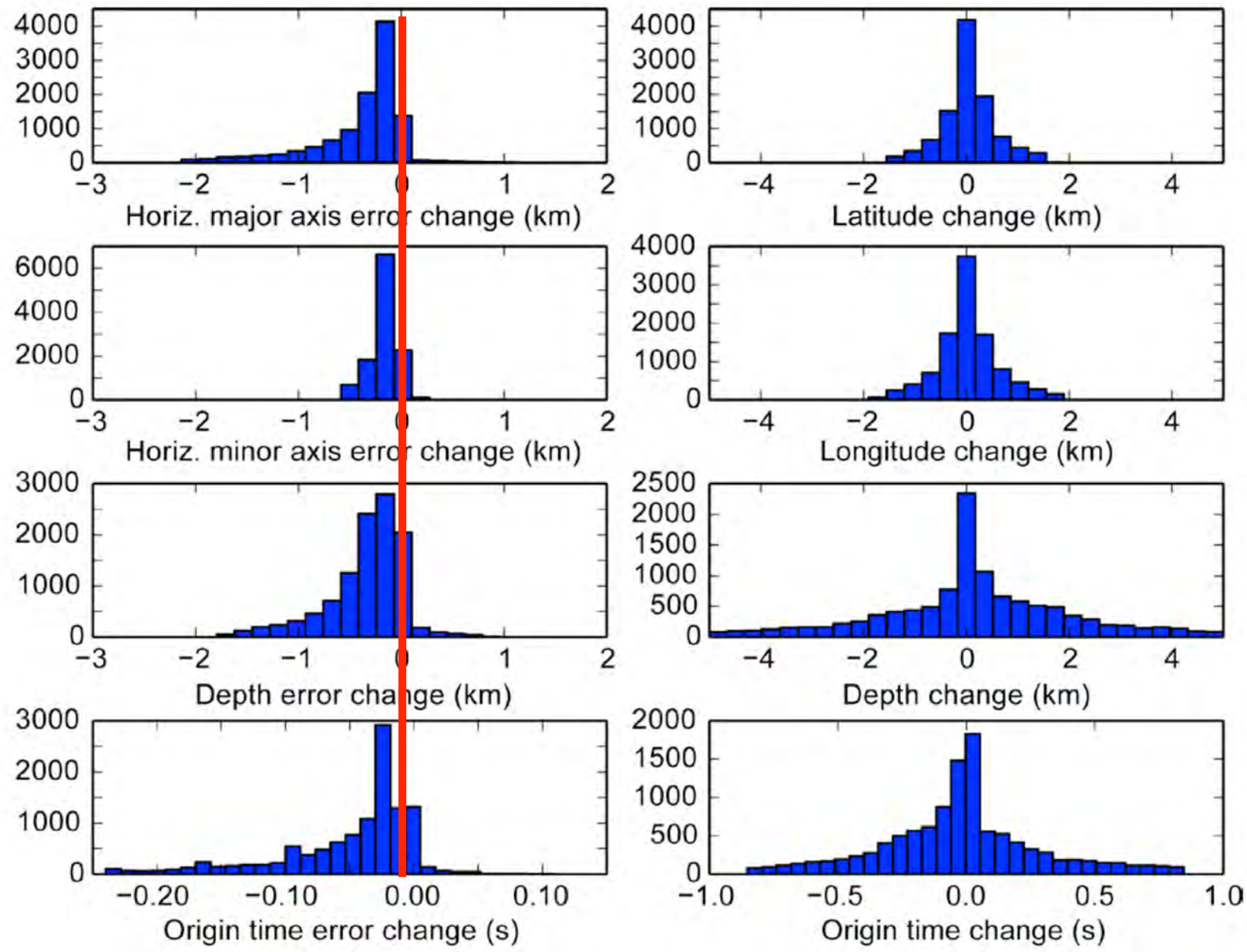
- Processed with dbdetect
  - 38k S picks
  - P/S = 7.53
- Processed with dbdetect + dbshear
  - 267k S picks
  - ~600% increase
  - P/S = 1.08



Location Uncertainty Statistics

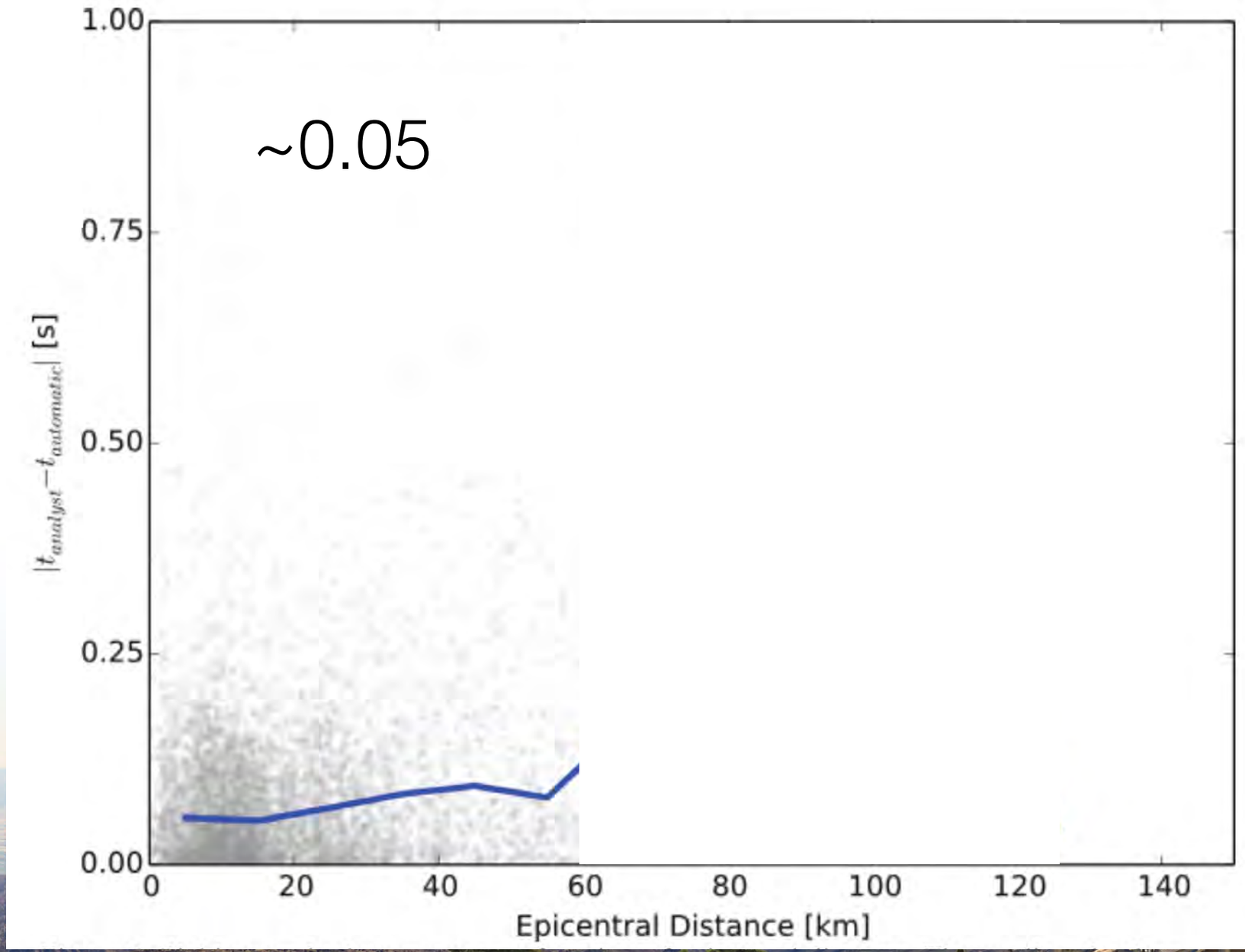
- 11,197 event locations calculated with dbgenloc
- Uncertainty generally decreased
- No systematic bias in location

Uncertainty Change *Location Change*



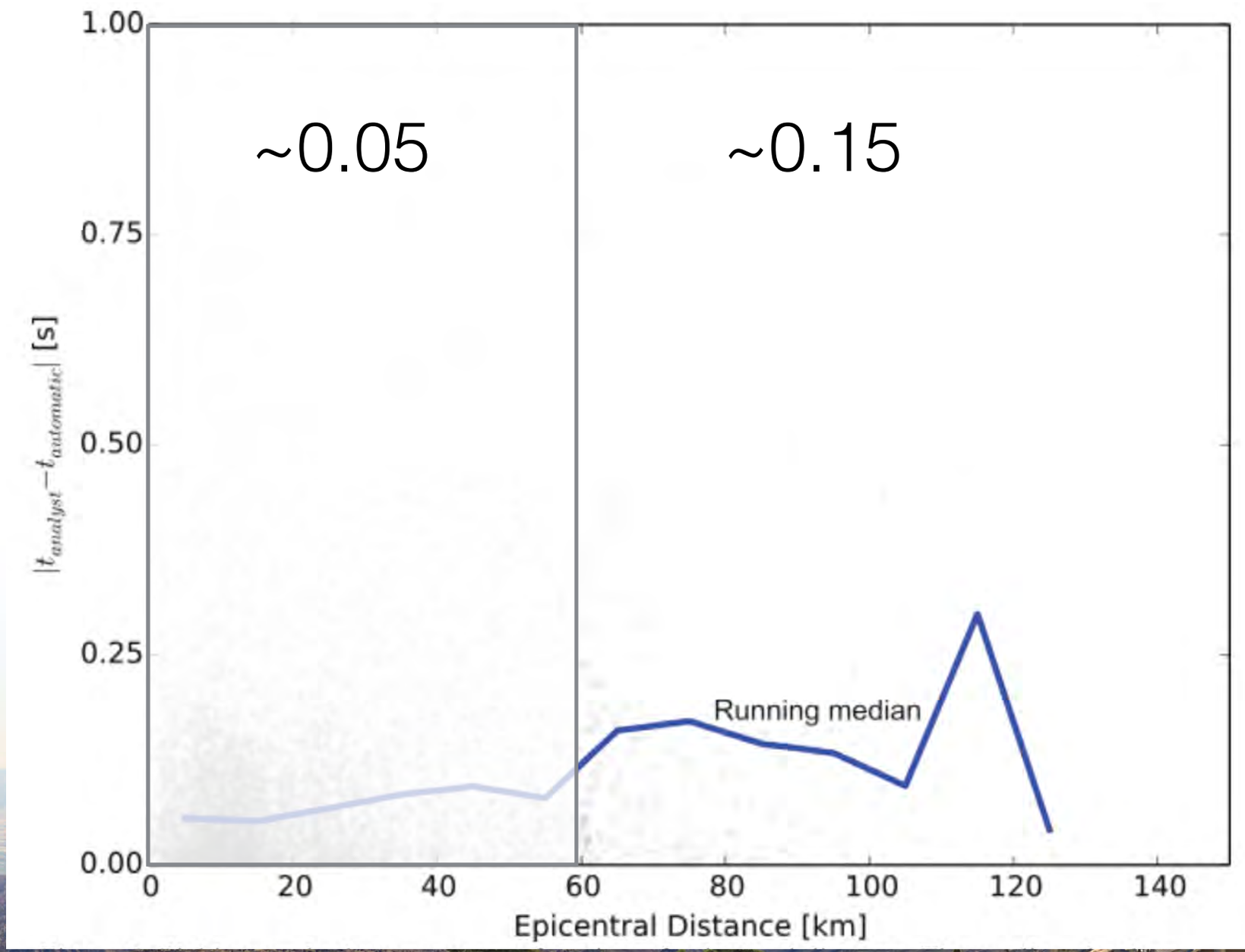
Median Pick Residual vs Distance

- ≲ 60 km



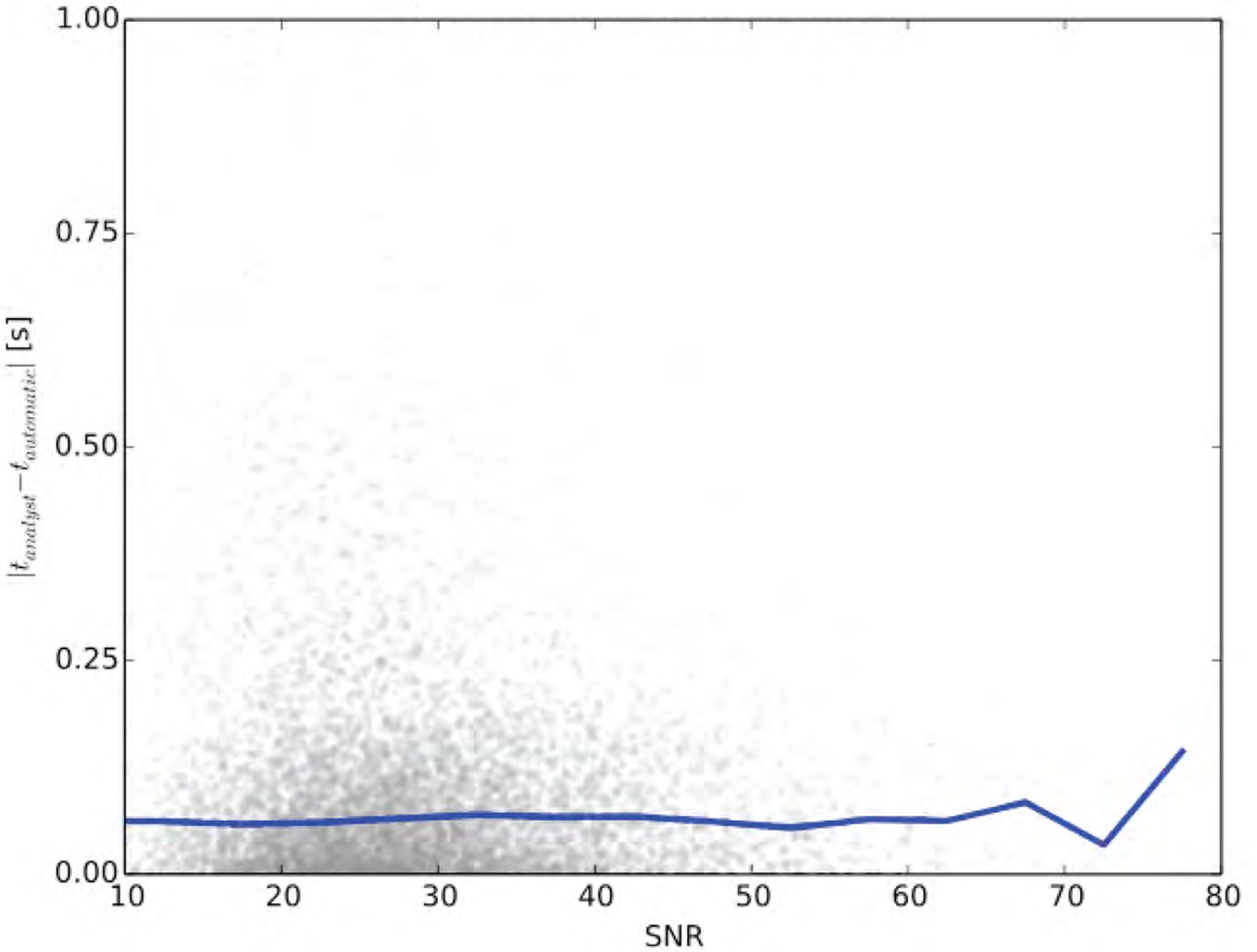
Median Pick Residual vs Distance

- ≲ 60 km
- ≲ 120 km



Median Pick Residual vs SNR

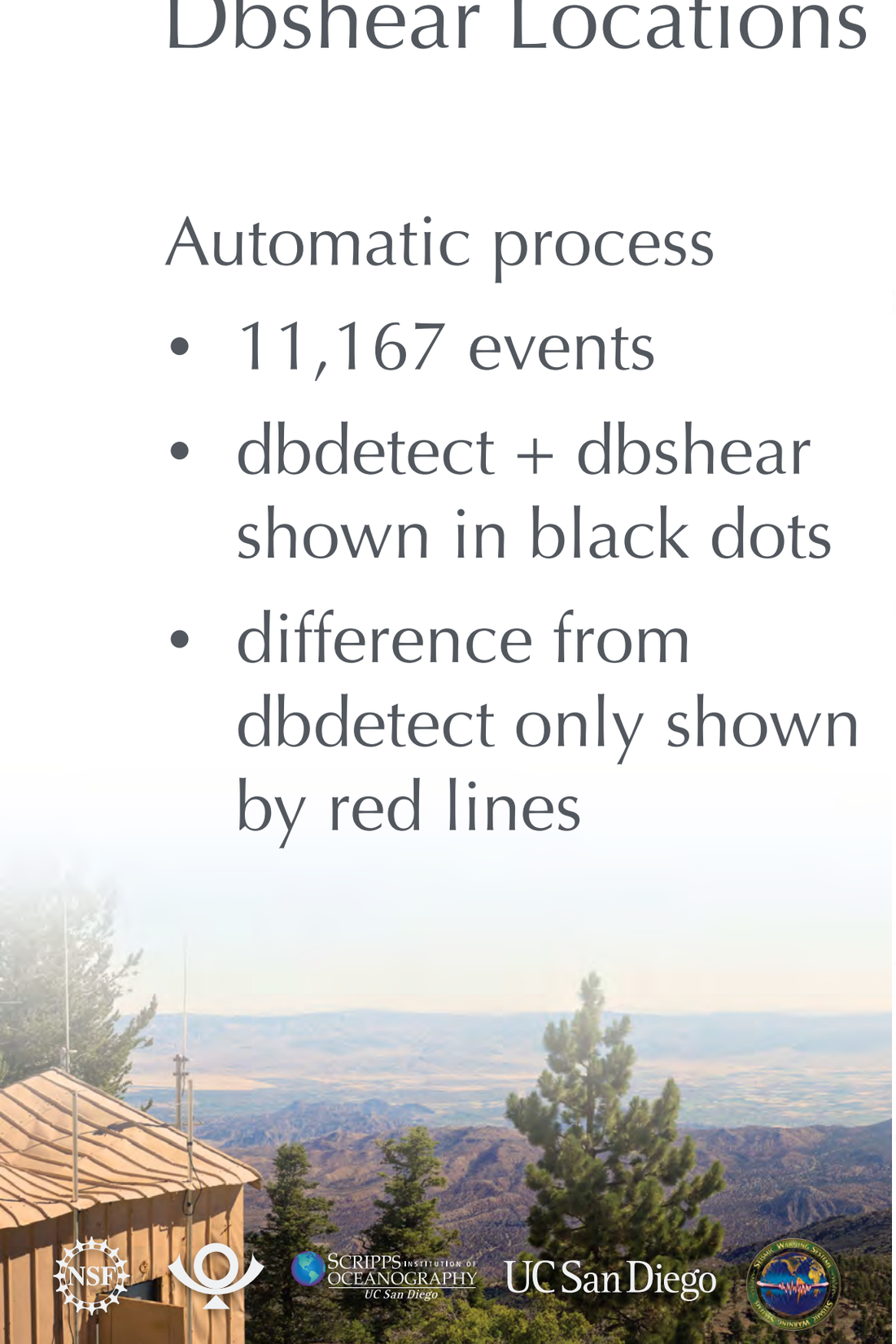
- Median residual value
  - snr > 10
  - ~0.07 seconds

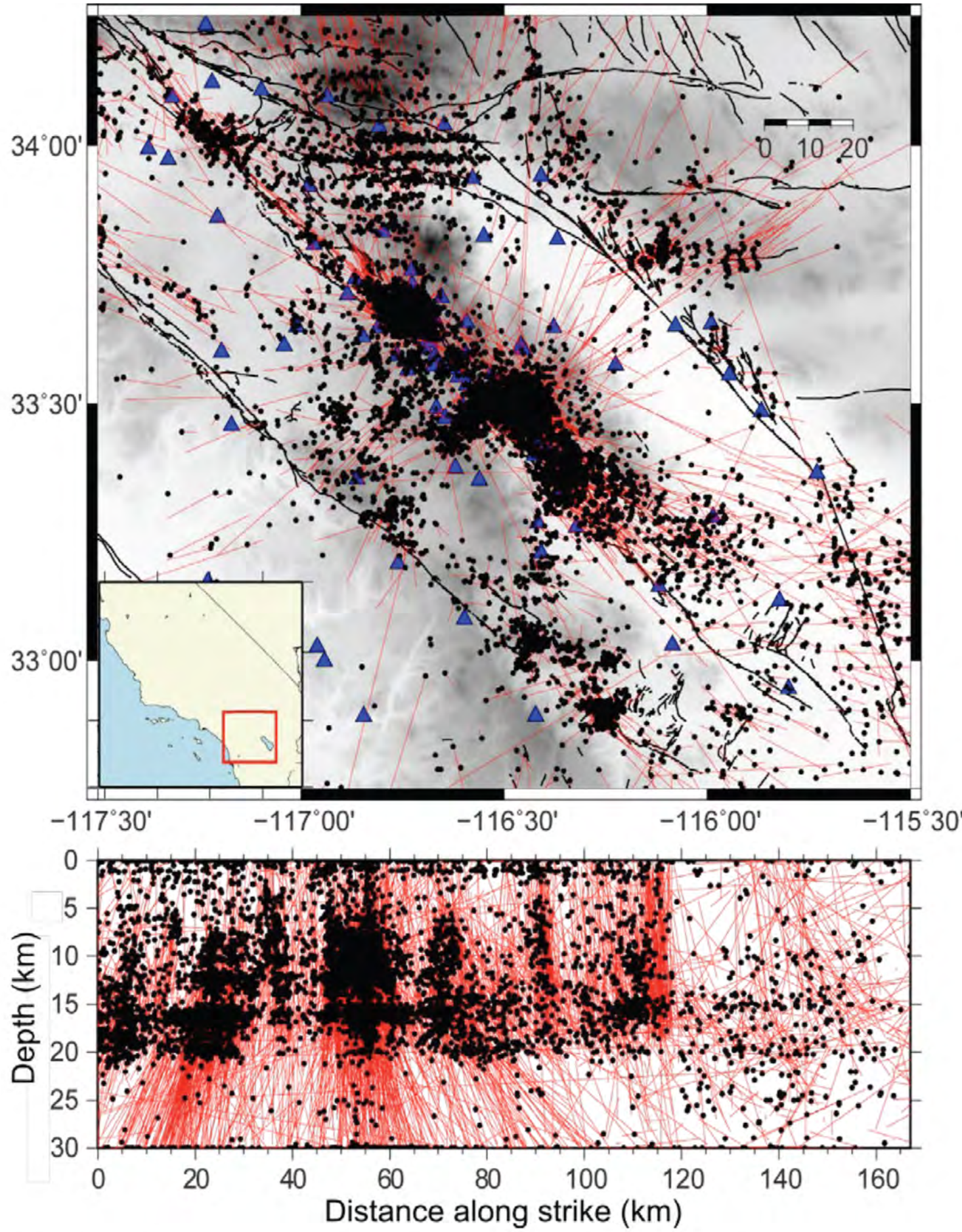


Dbshear Locations

Automatic process

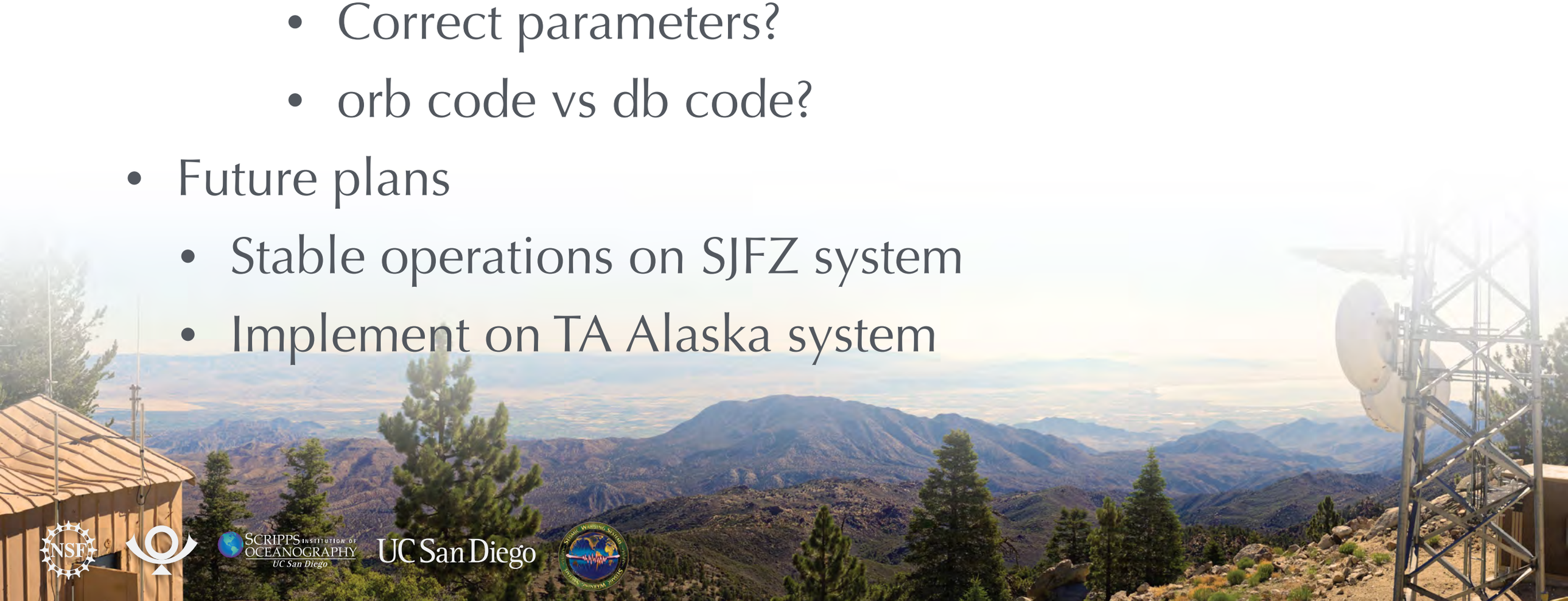
- 11,167 events
- dbdetect + dbshear shown in black dots
- difference from dbdetect only shown by red lines





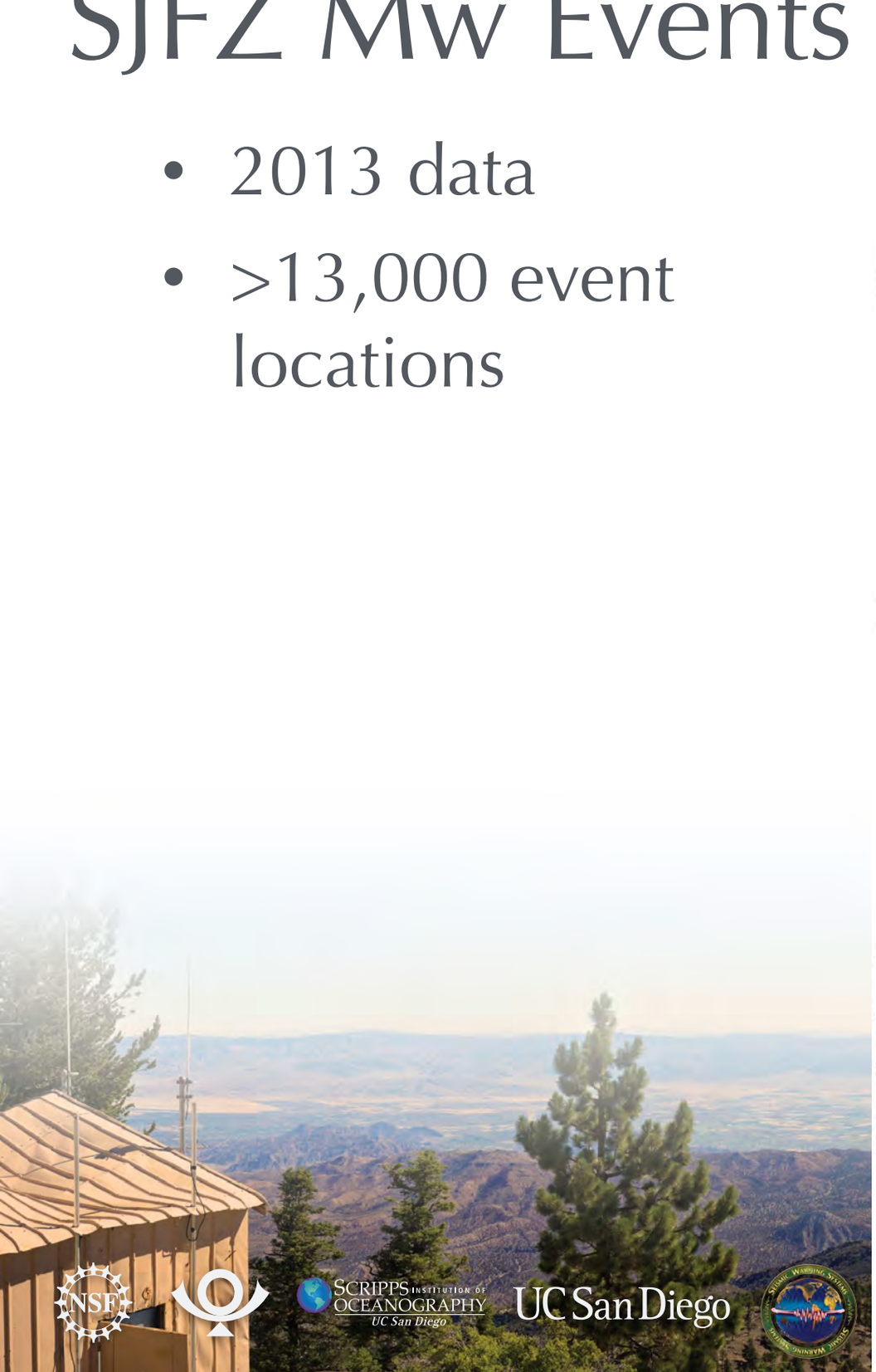
Future work

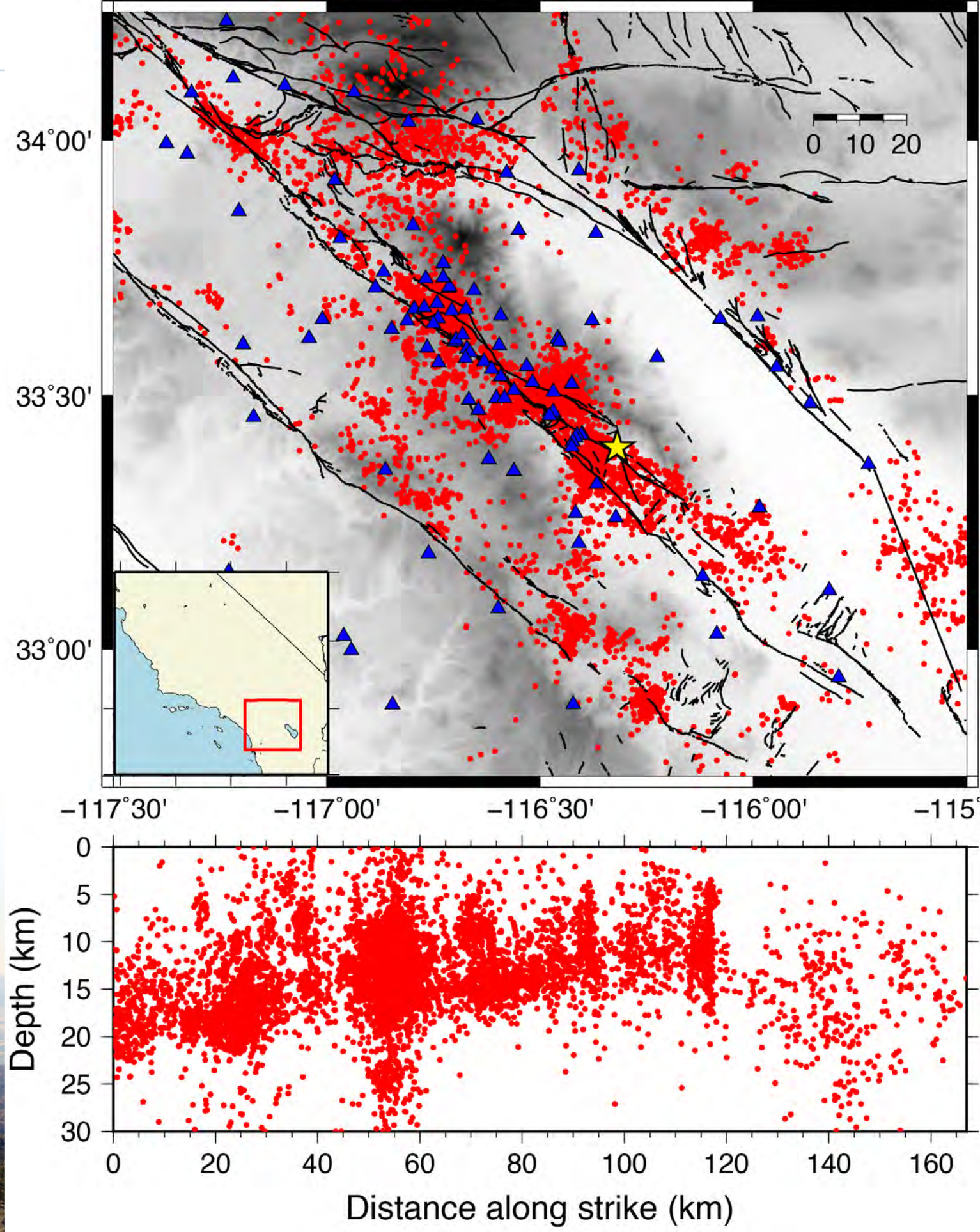
- Current status
  - Works on SJFZ database
  - Testing on SJFZ realtime system
    - Disappointing results
      - Correct parameters?
      - orb code vs db code?
- Future plans
  - Stable operations on SJFZ system
  - Implement on TA Alaska system



SJFZ Mw Events

- 2013 data
- >13,000 event locations





dbmw process

- Displacement source spectrum model

$$A(f) = \frac{\Omega_0 \cdot \exp\left(-\pi f t^*\right)}{1+(f/f_c)^n}$$

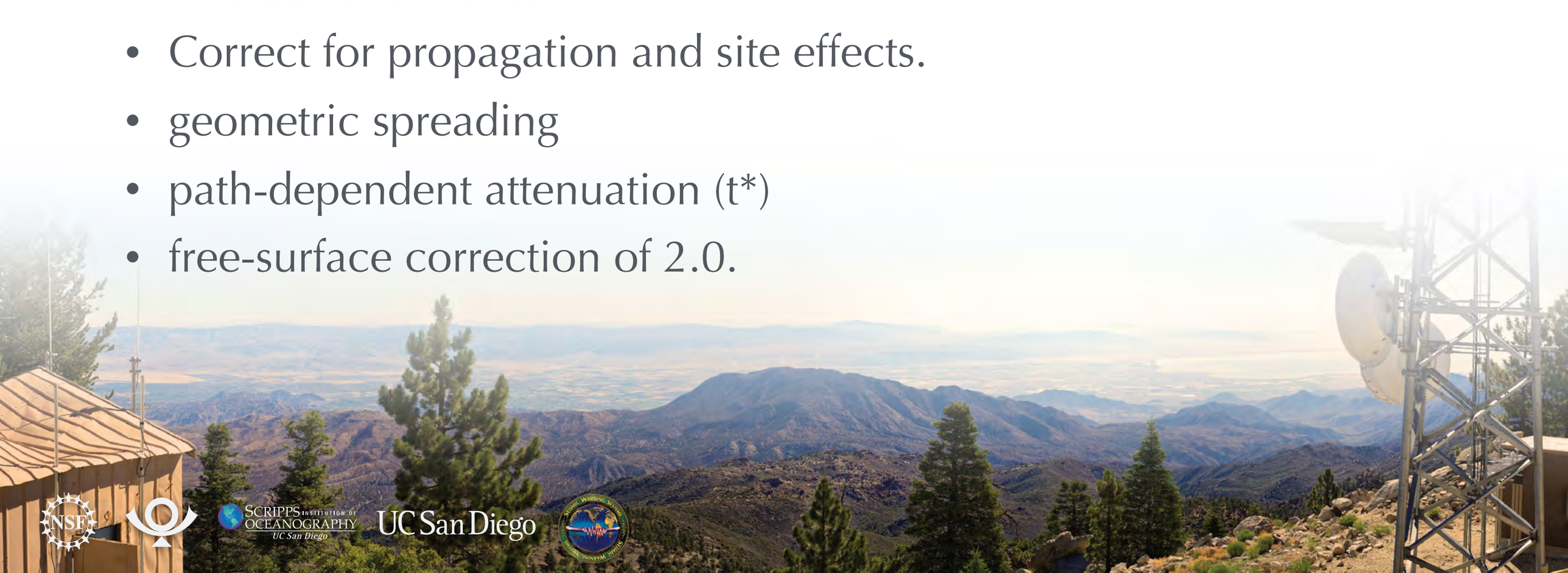
dbmw process

- Displacement source spectrum model
- for each available event and station
  - demeaned
  - multi taper spectrum estimator
  - corrected for instrument response
- Vector amplitude spectrum

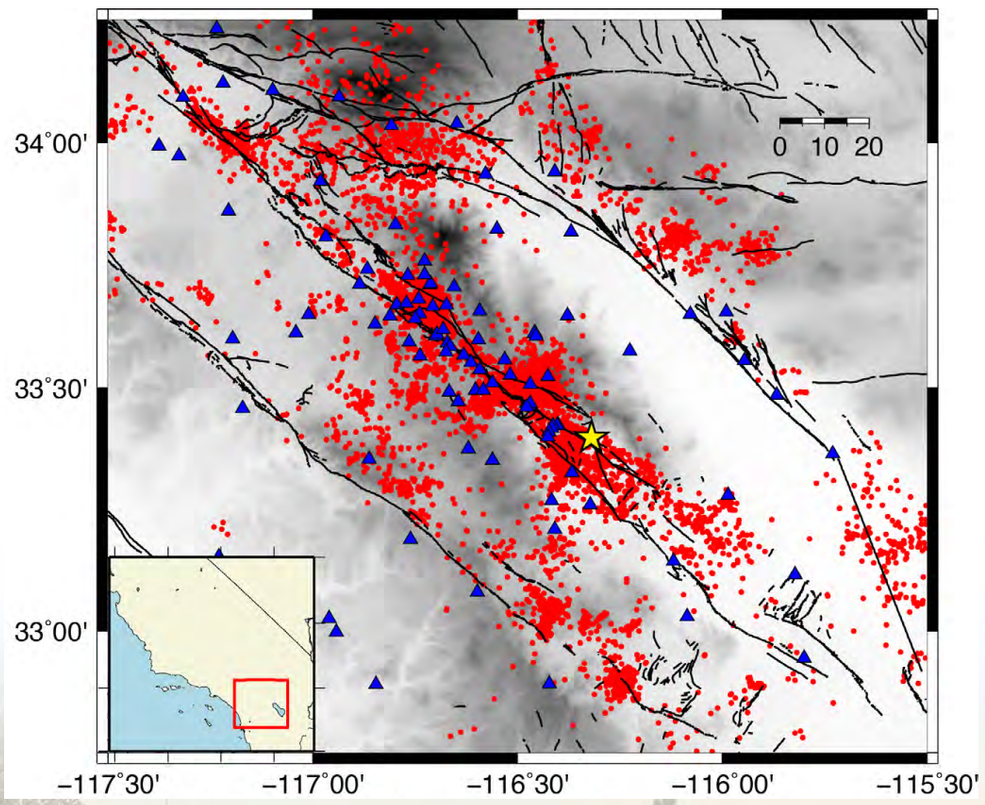
$$M = \sqrt{N^2 + E^2 + Z^2}$$

dbmw process

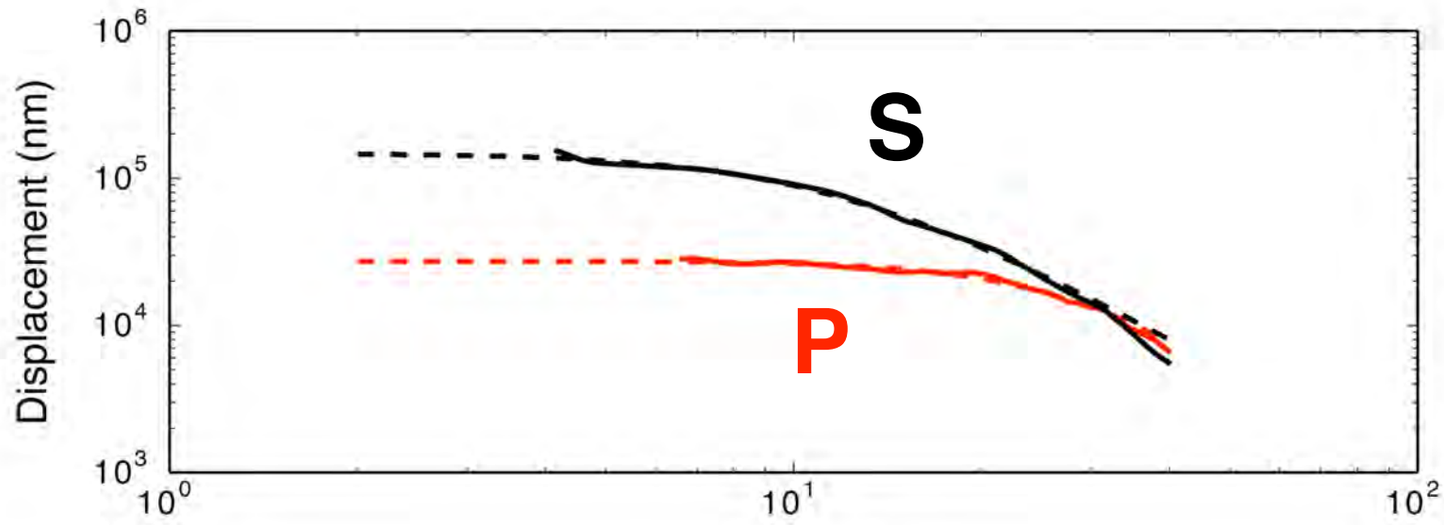
- > 75% of the SNR values above 5.0.
- < 5 spectra were left for either P- or S-waves, the event is skipped.
- spectra are corrected for radiation pattern
  - 0.55 for P-waves
  - 0.62 for S-waves
- Correct for propagation and site effects.
- geometric spreading
- path-dependent attenuation (t*)
- free-surface correction of 2.0.



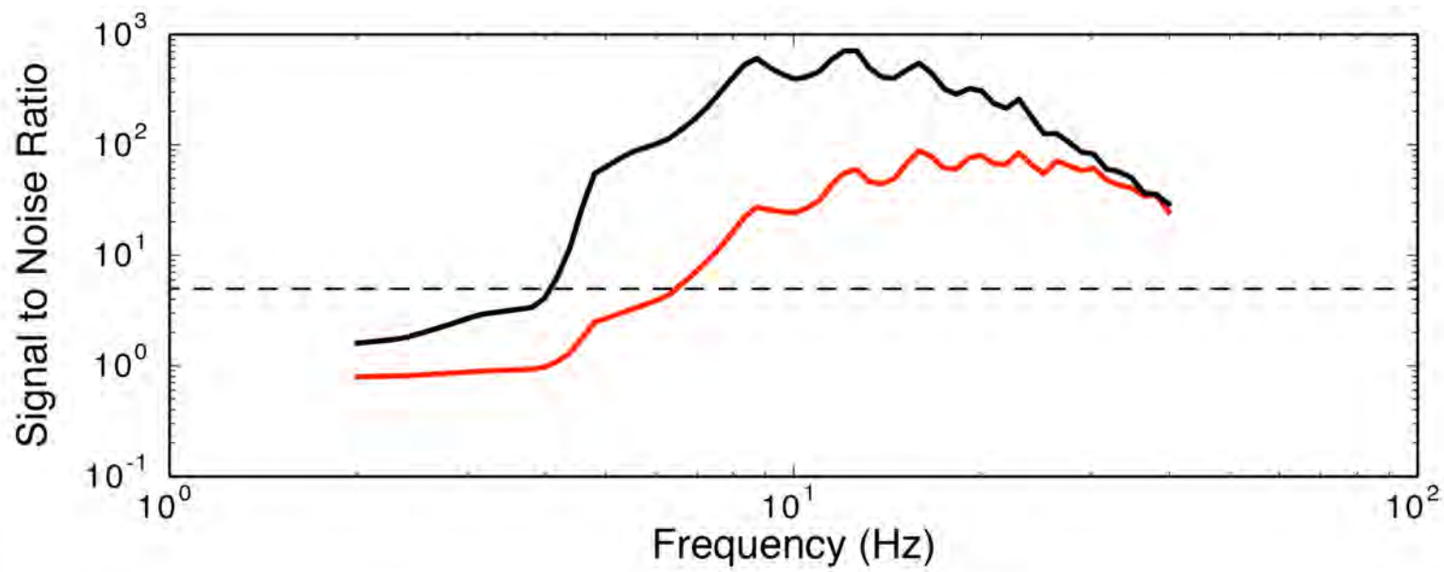
Local Event, 10 P and 10 S phases
M_w 1.35, M_l 0.9



Stacked Displacement Spectra

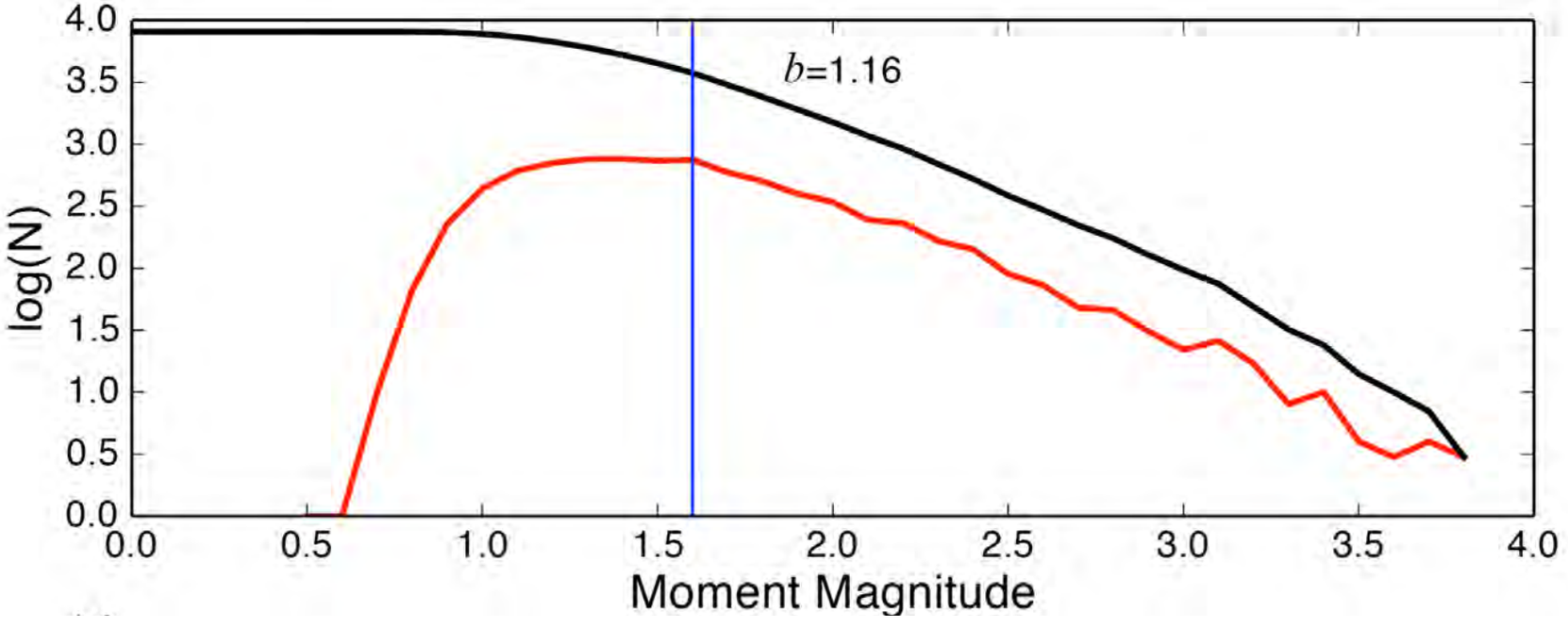


Stacked Signal to Noise Ratio

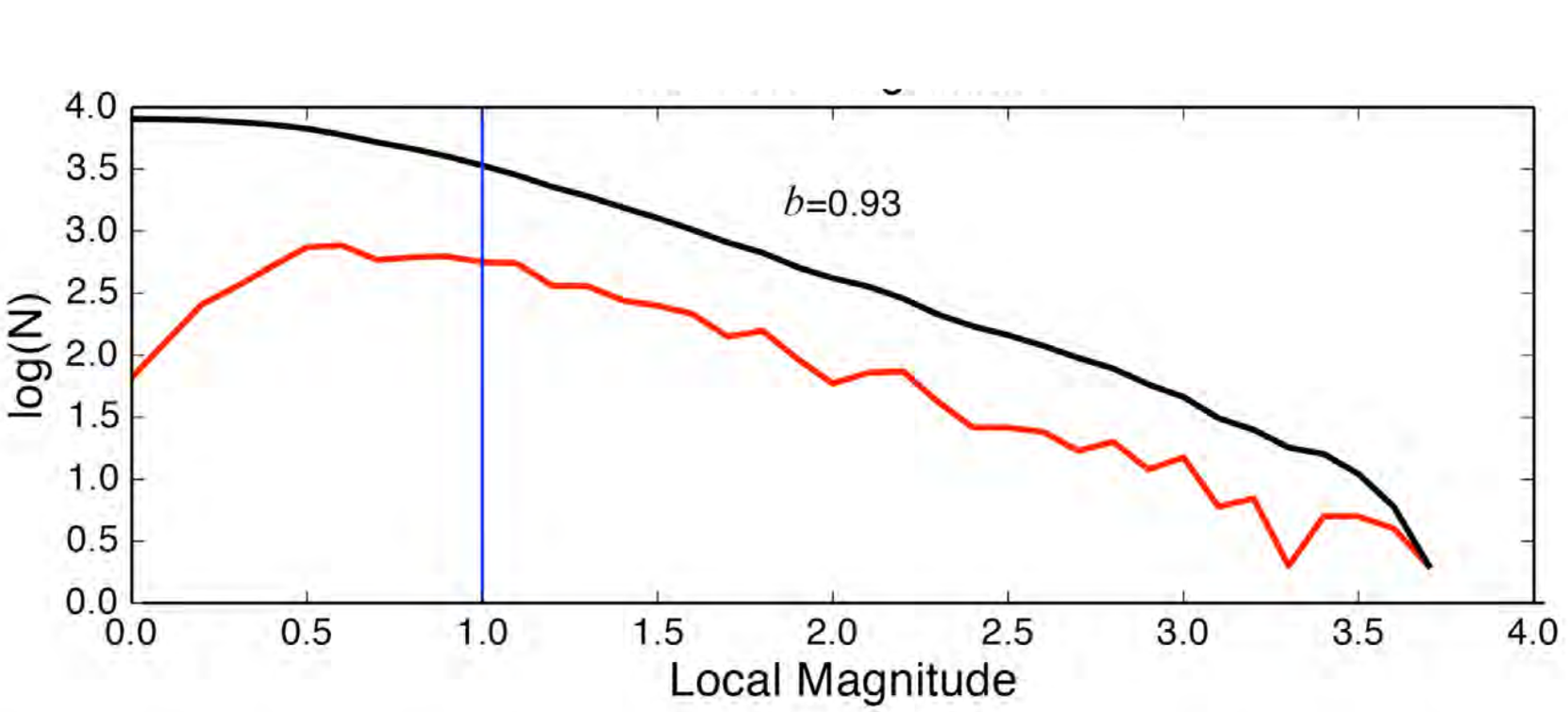


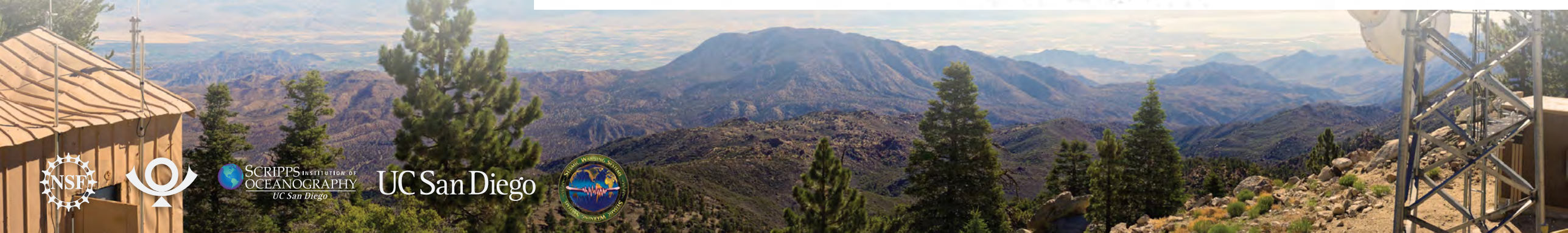
b values

- M_W 1.16



- M_l 0.93





SJFZ Scaling Relationships

- Slope of the best-fitting line (red) in the upper panel is 1.13
  - Expected 1.5 from Hanks & Kanamori (1979).
- $M_w \sim M_L$ around 3.5
- $M_L = 0 \rightarrow M_w \sim 0.88$